Abstract

This is a \LaTeX{} package that provides macros based on TikZ to draw a game tree. The main idea underlying the core macros here is the completion of a whole tree by using a sequence of simple ‘parent-child’ tree structures, with no longer nested relations involved like the use of grandchildren or great-grandchildren. With the \texttt{istgame} package, you can draw a game tree as easily as drawing a game tree with pen and paper.

KEYWORDS: game trees, nodes, branches, information sets, continuum of branches, subgames

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0 Changes and remarks

0.1 Changes

Some macros have been changed and removed. Those who have used these changed and removed macros may want to find and replace the followings:

<table>
<thead>
<tr>
<th>ver. 1.0</th>
<th>ver. 2.0 or later</th>
</tr>
</thead>
<tbody>
<tr>
<td>\istb.</td>
<td>\istbt</td>
</tr>
<tr>
<td>\xtInfoset'</td>
<td>\xtInfoset</td>
</tr>
<tr>
<td>\xtInfosetO'</td>
<td>\xtInfosetO</td>
</tr>
<tr>
<td>\setistgrowkey</td>
<td>\setxtgrowkey</td>
</tr>
</tbody>
</table>

**Changed and removed macros**

- The macro name \istb.(terminal version) has been changed to \istbt (terminal version).
  - This is the opportunity cost of having a new macro \istB.
- The two (unsatisfactory) macros \xtInfoset' and \xtInfosetO' have been removed.
  - The macro \xtInfosetO is completely redesigned, so that we do not need the macro \xtInfosetO' any more.
  - No reasons could be found to keep (even for the backward compatibility) the swap versions \xtInfoset' and \xtInfosetO', except for the inconvenience to do ‘find and replace.’
- To keep consistency in naming macros, \setistgrowkey is renamed as \setxtgrowkey.

**Redesigned macros and the environment**

- \xtInfosetO: completely redefined to improve its function
  - Now a sloped information set is possible.
  - It connects two nodes like \xtInfosetO(coor1)(coor2), but if the two coordinates are identical it represents a singleton information set by a circle by default.
  - This change does not seem to cause much harm, but be aware that the swap version \xtInfosetO' has been removed and replaced by \xtInfosetO.
  - Be aware also that the way to change the height (1em by new default) of an information set has been changed, though you might not see much difference if you have only used the default information sets.
  - With new macros \xtCInfoset and \xtCInfosetO, a curved (even skewed curved) information set is now possible.
- istgame environment: (internal change)
  - Now the each value of the option of xscale and yscale, if exists, is extracted and saved at \xtxscale and \xtyscale, respectively. The value of scale is also saved at \xtscale only when it is used without xscale nor yscale. These values are internally used to get the best outputs of trees in many ways.
  - If the TikZ arrow option -> exists in the option list of an istgame environment, you can globally control the arrow-end-shorten value (by default, shorten >=0pt) by using a new macro \setistgameshorten. This is to get a better result of branches with arrows.
- Some changes that you might not notice have been made, including:
  - The core macros \istroot, \istb, and \endist have literally been redefined for some purposes, but this makes no difference to users.
  - The options thin and solid have been added to the definitions of basic node styles.
  - Some default values have been slightly changed.
0.2 What’s new

Some new functions

- **input mode changer** (math or text) for important labels: owners, action labels, and payoffs
  - \texttt{\setistmathTF} as the input mode changer for the important labels
  - \texttt{\setistmathTF*} having additional function as the *text font style changer*

- **curved (even skewed) information sets**
  - \texttt{\xtCInfoset} for curved information sets
  - \texttt{\xtCInfosetO} for curved bubble type information sets

- **enhanced continuum of branches** (making \texttt{\istcntm} and \texttt{\istcntmarc} obsolete)
  - \texttt{\istrootcntm} for a continuum triangle
  - \texttt{\istrootcntmA} for a continuum arc (with \texttt{\istbA})*
  - \texttt{\cmtmAInfoset} and \texttt{\cmtmAInfosetO} for information sets for a continuum of branches

- **arrows and middle arrows** on branches
  - controllable arrow option \texttt{-->} with \texttt{\setxtarrowtips} and middle arrow tip styles
  - \texttt{\xtShowMidArrows} and \texttt{\xtShowArrows}

- and some more
  - \texttt{\istB} for dual action labels
  - \texttt{\xtTimeLineH}, \texttt{\xtTimeLineV}, \texttt{\xtCommentTo}, \texttt{\xtCommentFrom}, etc.

List of new macros

- \texttt{\istbt(*)}: terminal version of \texttt{\istb(*)} (replacement of the removed macro \texttt{\istb.(*))}
- \texttt{\istB(*)}: dual action label version of \texttt{\istb(*)}
- \texttt{\istBt(*)}: terminal version of \texttt{\istB(*)}
- \texttt{\istbA(*)}: alternative version of \texttt{\istb(*)} (intended to work with a continuum arc)
- \texttt{\istbAt(*)}: terminal version of \texttt{\istbA(*)}

- \texttt{\setistmathTF}: input mode changer (math or text) for owners, action labels, and payoffs
  - \texttt{\setistmathTF*}: input mode and font style changer for owners, action labels, and payoffs

- \texttt{\xtCInfoset}: (curved version) curved information set
- \texttt{\xtCInfosetO}: (curved oval version) curved oval type information set
- \texttt{\xtCInfosetOTurnX}: turns X circles of \texttt{\xtCInfosetO} (to use it just in case)

- \texttt{\xtInfoset*}: prints owners according to the input mode as set by \texttt{\setistmathTF(*)}
- \texttt{\xtInfosetO*}: prints owners according to the input mode as set by \texttt{\setistmathTF(*)}
- \texttt{\xtInfosetOwner*}: prints owners according to the input mode as set by \texttt{\setistmathTF(*)}

- \texttt{\xtActionLabel*}: prints action labels according to the input mode set by \texttt{\setistmathTF(*)}
- \texttt{\xtPayoff*}: prints payoffs according to the input mode as set by \texttt{\setistmathTF(*)}

- \texttt{\xtInfosetOwner*}: prints payoffs according to the input mode set by \texttt{\setistmathTF(*)}

- \texttt{\setxtinfosetstyle}: changes line the style (line style, fill, etc.) for all information sets
- \texttt{\setxtinfosetlayer}: changes the layer of information sets
- \texttt{\setxtsubgamelayer}: changes the layer of \texttt{\xtSubgameBox} and \texttt{\xtSubgameOval}
- \texttt{\setistgameshorten}: value of the key \texttt{shorten >} in istgame environment option list

- \texttt{\cntmdistance}: analogous to \texttt{\xtdistance}, for a continuum of branches
- \texttt{\cntmdistance*}: incorporates \texttt{\cntmdistance} with \texttt{\xtdistance}
- \texttt{\istrootcntm}: \texttt{\istroot + cntm}, printing a continuum of branches
- \texttt{\istrootcntm'}: swap version of \texttt{\istrootcntm}
- \texttt{\istrootocntm}: (oval version) \texttt{\istrooto + cntm}, printing a continuum triangle
- \texttt{\istrootocntm': swap version of \istrootocntm}
- \texttt{\cntmpreset}: controls a continuum of branches (line style, color, size, fill color)
- \texttt{\cntmpreset*}: controls a simple triangle continuum of branches with no background color
\textbullet \ cntmistb: similar to \istb for the outermost branches of a continuum triangle
\textbullet \ cntmistb*: draws solid nodes at the ends of the continuum outermost branches
\textbullet \ istrootcntmA: \istroot + cntmA, printing a continuum arc
\textbullet \ istrootcntmA': swap version of \istrootcntmA
\textbullet \ istrootocntmA: (oval version) \istroot + cntmA, printing a continuum arc
\textbullet \ istrootocntmA': swap version of \istrootocntmA
\textbullet \ cntmApreset: controls the features of a continuum arc
\textbullet \ cntmAlayerpreset: sets the layer of a continuum wedge (with fill color)
\textbullet \ cntmAistb: similar to \istb for the outermost branches of a continuum arc
\textbullet \ cntmAistb*: draws solid nodes at the ends of the continuum arc outermost branches
\textbullet \ cntmAInfoset: prints an information set for a continuum arc
\textbullet \ cntmAInfosetO: oval version of \cntmAInfoset
\textbullet \ xtShowEndPoints*: shows additionally the outermost endpoints of a continuum of branches
\textbullet \ xtHideEnpPoints*: turns off only the endpoints of a continuum of branches
\textbullet \ cntmAexpostShowEndPoints: shows the two endpoints of a continuum arc
\textbullet \ setxtarrowtips: works through \text{-}\text{-} to control the features of middle arrow tips
\textbullet \ xtShowMidArrows: shows arrows in the middle of branches
\textbullet \ xtHideMidArrows: hides middle arrows drawn by \xtShowMidArrows
\textbullet \ setxtshowmidarrows: controls the middle arrows on branches in a simple tree
\textbullet \ xtShowArrows: shows arrows at the ends of branches with endpoints
\textbullet \ xtHideArrows: hides arrows drawn by \xtShowArrows
\textbullet \ xtHideArrows*: hides arrows but with endpoints remained
\textbullet \ setxtshowarrows: controls the features of the arrows shown by \xtShowArrows
\textbullet \ xtTimeLineH: a horizontal time-line
\textbullet \ xtTimeLineH': a horizontal time-line with a label at the other end
\textbullet \ xtTimeLineV: a vertical time-line
\textbullet \ xtTimeLineV': a vertical time-line with a label at the other end
\textbullet \ xtCommentTo: to leave a comment to a node from a relative coordinate
\textbullet \ xtCommentFrom: to leave a comment from an absolute coordinate to a node
\textbullet \ xtCureslopedlabelsNS: cures the Ti\textsc{z} issue of sloped labels with asymmetric scales
\textbullet \ xtCureslopedlabelsEW: same, for a tree growing eastwards or westwards

The last two macros are for only temporary use and could be removed at any time.

**List of new arrow styles**

\textbullet \text{-}\text{-}: (controllable) middle arrow tip, taking one optional argument
\textbullet \text{-}\text{-}\text{-}: double middle arrow tip
\textbullet \text{-}\text{-}\text{-}: triple middle arrow tip
\textbullet \text{-}: circle middle arrow tip
\textbullet \text{-}: cross middle arrow tip

### 0.3 How to read this document

As a Ti\textsc{z} user, if this is your first read of this manual, all you need to read is Section 1 entitled “Getting started.” That’s only four pages long. (You can find a little secret at the first part of Section 1.3 entitled “Complete examples for desperate users.”) Every example in this document is provided with its complete codes you can copy to use. Now you can go to Section 1 to get started!

If you are not urgent, you can continue to read sections on core macros up to Section 5. That’s about twenty pages total. Still more time? Then read Section 6 (entitled “Important labels: players, action labels, and payoffs”) and Section 7 (entitled “Input mode and text font style changer”). That’s about thirty pages all total.

Throughout the manual, just disregard the parts with marks including “fine-tuning” or “not for most users,” if you are not an experienced user of this package. Just reading first part of each section will suffice most users to draw game trees in almost all cases, hopefully.

If you you are an experienced user of the \istgame package, enjoy every detail of the package.
0.4 Remarks

Rules of thumb for the usage of delimiters Though the rules are not strictly observed, it might be useful to go over the rules of thumb for the usage of delimiters.

• { }: contents, texts, important dimensions (mandatory or optional)
• [ ]: usual options, positions or directions, node types, fill color
• ( ): coordinate related arguments, dimension as the last optional argument, special purposes
• < >: angles (or directions), special purposes (mostly used right before { })
• + .. +: only for the local change of level and sibling distances with istroot and its friends
• ! !: midpoint factor only for curved information sets

As for the order of delimiters, the (somewhat loose) rules are as follows:

• Generally, all macros are designed to avoid leaving an empty argument like [], as possible as they can do. (This is input minimalism for lazy users including myself!)
• < > is used just before { }, except for istb and its friends.
• ( ) as the last optional argument is for dimensions, like (1em) or (3pt).
• The order mostly looks like <>{}[] or <>{}[](), especially after a mandatory argument.

Optional versions of macros Some macros have a starred(*) version or a swap(’) version, for example, istb* or istroot’.

• * version: just another version with different functions (in some cases, it’s quite different)
• ’ version: clockwise arrangement of branches or its related version

Global macros Some macros have global effects, so you can use them outside of the istgame environment or even in the preamble of your document, but with very great caution.

The following macros, all prefixed by \setist..., can be used outside of the istgame environment, to change the default values of the options:

• \setistgamefontsize{<text size>} (default: \normalsize)
• \setistgameshorten{<arrow end shorten dim>} (default: 0pt)
  – This works only when -> exists in the option list of the istgame environment.

Though it is not recommended, you can use all the macros prefixed by \setist... inside or outside of the istgame environment to change the default values.

• \setistmathTF, \setistmathTF* (initially: 011)
• \setistdefaultnodeinnersep (default: 1pt)
• \setistdefaultnodeoutersep (default: 0pt)
• \setistdefaultnodedrawcolor (default: black)
• \setistdefaultnodefillcolor (default: white)
• \setist<...>NodeStyle
• \setistgrowdirection, \setistgrowdirection’ (default: south):
  – You may not want to use (but still can use) this outside of an istgame environment.

You can even do, in the preamble of your document, like:

\usepackage{istgame}
\setistgamefontsize{\normalsize}
\setistdefaultnodedrawcolor{black}
\setistSolidNodeStyle{2.4pt}
\setistgameshorten{.3pt}
\setistmathTF011
The node styles such as ellipse node and rectangle node has white as the default background color. This means that if the paper color of your document is not white, say, blue!16, you might not satisfy the results because the nodes have white background. In this case you can resolve the conflict by adding the following two lines at the very first of your document:

\papercolor{blue!16}
\setistdefaultnodedefillcolor{blue!16}

The background color of the TeXShop preview in the dark mode of macOS Mojave is very similar to black!16.

**Known problem with the tikz-qtree package**  It seems that tikz-qtree changes node anchors. So, with the tikz-qtree package uploaded, you will get unexpected results when you draw a game tree by using the tree library in TikZ. Since istgame is based on the tree library, it is also affected by tikz-qtree, resulting in unexpected outputs.

The best way to resolve this problem is that you DO NOT LOAD tikz-qtree when you draw game trees with TikZ. If, for some reason, you need to load tikz-qtree when you draw a game tree by using the istgame package, a temporary solution to resolve the conflict is to add the TikZ option edge from parent path in the option list of istgame environment as follows:

```
% TikZ conflict resolution (only with \usepackage{tikz-qtree})
[
  edge from parent path={\tikzparentnode} -- {\tikzchildnode}]
```

### 0.5 Previous changes (up to version 1.0)

A considerable number of macro names have been changed in the version 0.8 (Jan. 17, 2017) of this package. The following old macro names in any previously written documents using codes in istgame ver. 0.7 or before, should be replaced by the new names, accordingly.

Also, \istroot*, \istcntm*, and \xtInfoset* should be replaced by \istrooto, \istcntmarc, and \xtInfoseto, respectively, in the version 1.0 or later.

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</tbody>
</table>

\footnote{The istgame package of the version older than ver. 1.0 had been distributed via the KTUG (Korean TeX Users Group) Private Repository.}
1 Getting started

The package istgame provides macros built on TikZ to draw game trees. The core macros provided with this package are \istroot, \istb, and \endist. \istroot pins down the root of a tree or a subtree, \istb represents a branch, and \endist indicates the end of drawing a simple tree. Without \endist, the tree is NOT actually drawn, with no error messages produced. A tree drawn by the sequence of \istroot-\istb-\endist is a simple tree. You can draw a whole game tree by repeatedly connecting these simple tree structures.

Here, the prefix ‘ist’ stands for ‘it’s a simple tree.’ You can also read it as ‘insung’s simple tree’ if you would like.

The package istgame depends on the packages tikz, xparse, and expl3.

To use the istgame package you must load the package in the preamble of your document:

\usepackage{istgame}

The package uses the following TikZ libraries:

trees, calc, arrows, shapes, positioning, backgrounds, fit, decorations.markings, and also loads patterns and intersections for additional use.

1.1 Getting-started example: a simple tree

Let us get started with a simple self-explanatory example:

\begin{istgame}
\istroot(0)(0,0) \% names the root as (0) at (0,0)
\istb % endpoint will be (0-1), automatically
\istb % endpoint will be (0-2), automatically
\istb % endpoint will be (0-3), automatically
\endist % end of simple (parent-child) structure
\end{istgame}

The resulting tree has the height of 15mm and the distance between two neighbor endpoints (not shown) is also 15mm by default. In TikZ, the height is called the level distance and the distance between two neighbor endpoints is called the sibling distance.

If the second parenthesis argument of \istroot is omitted, it is regarded as (0,0) by default, otherwise it is necessary to specify the coordinate from which a simple tree starts.

1.2 Connecting simple tree structures

Basically, in order to draw a whole game tree, we just repeat the simple \istroot-\istb-\endist structure.

\begin{istgame}
\istroot(0) % names the root (0) at (0,0)
\istb % endpoint will be (0-1), automatically
\istb % endpoint will be (0-2)
\istb % endpoint will be (0-3)
\endist % end of simple (parent-child) structure
\istroot(c)(0-3) % names the subroot (c) at (0-3)
\istb % endpoint will be (c-1)
\istb % endpoint will be (c-2)
\endist
\end{istgame}
In the above example, the simple subtree is rooted at (0-3), names the subroot (c), and has two branches whose endpoints are automatically named (c-1) and (c-2), respectively.

Note that the user-defined names of the (sub)roots and the names of endpoints are arranged counterclockwise (from left to right) by TikZ at the endpoints of branches, which can be used as coordinates in the usual TikZ way.

### 1.3 Complete examples for desperate users

Basically, \texttt{\textbackslash istroot} designates a decision node and its owner (or a player), \texttt{\textbackslash istb} prints a branch coming out from the decision node with action labels and payoffs, and \texttt{\textbackslash endist} actually draws the tree structures. (One secret is that I almost always use only the basic features of the \texttt{istgame} package, discussed in this subsection.)

#### 1.3.1 How to put a decision node and its owner

\begin{verbatim}
\texttt{\textbackslash istroot(<decision node name>)(<root location>)<owner position>{<owner>}}
\end{verbatim}

The only mandatory argument of \texttt{\textbackslash istroot} is \texttt{(<decision node name>)} and all others are optional. If the \texttt{(<location>)} where the root or a decision node is placed is omitted, it is regarded as \texttt{(0,0)} by default. The position of an owner (or a player) is \texttt{<above>} (or equivalently, \texttt{<90>} degree) by default. The owner of a node is printed in text mode by default.

% Example: first try
\begin{verbatim}
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot(0)(0,0){Child}
    \istb{Good}[above left]{(0,2)}
    \istb{Bad}[above right]
\endist
\istroot(1)(0-2)<30>{Parent}
    \istb{Forgive}[above left]{(1,1)}
    \istb{Punish}[above right]{(-1,-1)}
\endist
\end{istgame}
\end{verbatim}

In fact, \texttt{\textbackslash istroot} and its variants have much more functions than these. Later, you can look into Section 4 on page 14 for more details.

#### 1.3.2 How to print branches with action labels and payoffs

\begin{verbatim}
\texttt{\textbackslash istb{<action label>}{<action label pos>}{<payoffs>}{<payoff pos>}}
\end{verbatim}

With the macro \texttt{\textbackslash istb}, you can draw a branch and put an action label and payoffs as optional arguments.

% Example: first try
\begin{verbatim}
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot(0){Child}
    \istb{Good}[above left]{(0,2)}
    \istb{Bad}[above right]
\endist
\istroot(1)(0-2)<30>{Parent}
    \istb{Forgive}[al]{(1,1)}
    \istb{Punish}[ar]{(-1,-1)}
\endist
\end{istgame}
\end{verbatim}
The positions of an action label and payoffs are specified as options right after each of the two. When you omit the position of payoffs, the package prints them naturally, but still you can change the location using an option like [left] or [above left]. For the positions of action labels and payoffs, you can use an abbreviation [al] for [above left] and similarly [ar], [bl], and [br]. The abbreviations [a], [b], [l], and [r] are also available.

Both of the action labels and payoffs are printed in math mode by default. (You can change the input mode for owners, action labels, and payoffs using a very useful macro \texttt{\istmathTF}, documented in Section 7 on page 36.)

In fact, \istb and its variants have much more functions than these. For more details, see Section 5, on page 18. If this is your first read of this manual, however, you don’t need to bother about all the details at the moment.

Following three sections are about an information set, a continuum of branches, and changing the direction of tree growing. If you do not need to use them now, the core macros \istroot, \istb, and \endist are all you need to know about drawing game trees of any size, small or big. Just connect simple trees to complete a whole tree.

### 1.3.3 How to put information sets

The macro \texttt{\xtInfoset} connects two nodes with a densely dotted line, by default, representing an information set.

\begin{verbatim}
\xtInfoset{<from coor>}{<end coor>}{<owner>}{<owner pos>}
\end{verbatim}

The two node coordinates are mandatory. You can put the owner of an information set as an optional argument. An owner is printed above (by default) the line in text mode, which can be changed. For more details about \xtInfoset, see Section 10 on page 45.

In the example below, the macro \xtInfoset is used to show an information set.

```
% Example: information set
\begin{istgame}
%\setistgrowdirection{\texttt{east}}
\xtdistance{15mm}{30mm}
\istroot(0){Alice}
  \istb(A)[al]{(2,2)}
  \istb(D)[ar]
\endist
\istroot(1)(0-2)<above right>{Alice}
  \istb(L)[al]
  \istb(R)[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)
  \istb(\ell)[al]{(4,2)}
  \istb(r)[ar]{(1,1)}
\endist
\istroot(3)(1-2)
  \istb(\ell)[al]{(3,2)}
  \istb(r)[ar]{(0,3)}
\endist
\xtInfoset(2)(3){Elaine}
\end{istgame}
```

The package also provides the macro \texttt{\xtInfosetO} to draw a bubble type information set. Just replace \xtInfoset with \xtInfosetO (see Section 10.2.1 on page 46).

You can also draw a curved information by using \texttt{\xtCInfoset} (Section 10.3) and even a curved bubble type by using \texttt{\xtCInfosetO} (Section 10.4). You can try now.
1.3.4 How to put a continuum of branches

Just use \lstrootcntm(\lstroot + \cntm), instead of \lstroot, to draw a continuum of branches.

\lstrootcntm(<decision node name>)(<root location>)(<owner position>){<owner>}

The macro \lstrootcntm works just like \lstroot, but it prints a background triangle in black!25, by default, representing a continuum of branches.

% Example: continuum of branches
\begin{istgame}[font=\scriptsize]
\lstrootcntm(0)(1)
\lstb{x}[x] \lstbm \endist
\xtdistance{10mm}{20mm}
\lstroot(1)(0-1)<120>{2}
\lstb{Y}[a]{x,1-x} \lstb{N}[a]{0,0} \endist
\end{istgame}

Here, \lstbm represents a missing (or an invisible) branch (see page 19).
You can also change the color and size of the triangle representing a continuum of branches. For more details on \lstrootcntm see Section 11.1, on page 56.

The package also provides the macro \lstrootcntmA to draw an arc to represent a continuum of branches. You can just replace \lstrootcntm by \lstrootcntmA to do that, but let us not try this now. (If you really want to try this now, you should change the first \lstb to \lstbA and then take out \lstbm in the above example. It is said not to try this now.) For more details on \lstrootcntmA see Section 11.2, on page 61.

You can use every options and macros you can use for the \tikzpicture environment with the \istgame environment. In the above example, font=\scriptsize is used as an option.

1.3.5 How to change the growing direction of a tree

With \setistgrowdirection or \setistgrowdirection', you can easily change the direction (south by default) to which a game tree grows, as shown in the example below.

% Example: \setistgrowdirection(')
\begin{istgame}[scale=1.2]
\setistgrowdirection'{east}
\lstroot(0)<180>{1}
\lstb{a}[a]
\lstb{b}[b]
\lstb{c}[b]
\endist
\xtdistance{10mm}{20mm}
\lstroot(1)(0-2)<135>{2}
\lstb{Y}[a]{x,1-x} \lstb{N}[b]{0,0} \endist
\end{istgame}

All you need to do is just to specify the direction you want, like \setistgrowdirection{west}, \setistgrowdirection'{east}, or \setistgrowdirection'{-45}. The prime version ('') is just to arrange branches clockwise (by default coutnerclockwise). In the above example, if you use \setistgrowdirection without the prime, the branches will be arranged counterclockwise, like a, b, and c from bottom to top. When changing the direction of a tree, you may want to relocate the owner and action labels. For more details, see Sections 9 (on page 41) and 6.3.2 (on page 33).

Now you are ready to draw any standard game trees such as all game trees in Osborne’s book.
2 Important distances: \texttt{\texttt{xtdistance}}

The length and direction of branches in a simple tree can be controlled by the macro \texttt{xtdistance}. Here, the prefix \texttt{xt} stands for extensive tree.

\begin{verbatim}
\% syntax: \texttt{xtdistance}
\texttt{xtdistance}[<level depth>]{<level dist>}{<sibling dist>}
\% defaults:
[1]{15mm}{15mm}
\end{verbatim}

The macro \texttt{xtdistance} sets or resets the level distance and the sibling distance, respectively. Note also that internally, for example, \texttt{xtdistance}{20mm}{30mm} assigns 20mm to \texttt{xtdist} and 30mm to \texttt{tsibdist}, which renew the default distances. It is effective until you change the distances by using another \texttt{xtdistance}.

![Diagram showing level and sibling distances]

You can use \texttt{xtdistance} at any time you want to change the length and the directions of branches. Since we are dealing with simple parent-child tree structures, \texttt{<level depth>} is 1 by default. (The level depth number other than 1 is not expected to be used.)

\begin{verbatim}
\% Example: \texttt{xtdistance}
\begin{istgame}
\texttt{xtdistance}{15mm} \% default
\texttt{xtdist}(0) \% names the root (0) at (0,0)
\texttt{xstb} \% endpoint will be (0-1), automatically
\texttt{xstb} \% endpoint will be (0-2)
\texttt{xstb} \% endpoint will be (0-3)
\texttt{endist} \% end of simple (parent-child) structure
\texttt{xtdistance}{15mm}{30mm} \% changes sibling dist
\texttt{xtdist}(a)(0-1) \% names the subroot (a) at (0-1)
\texttt{xstb} \% endpoint will be (a-1)
\texttt{xstb} \% endpoint will be (a-2)
\texttt{endist}
\end{istgame}
\end{verbatim}

Remark:

\begin{itemize}
\item Since \texttt{xtdist} and \texttt{tsibdist} are assigned values by \texttt{xtdistance}, you can use these values to do some calculation, for example, like \texttt{1.2*xtdist} or \texttt{1.5*tsibdist}.
\item The starred version \texttt{cntmdistance*} is provided to deal with a continuum of branches and \texttt{xtdistances} together, which is not documented at the moment. See Section 11.1.3, on page 58, for more details about \texttt{cntmdistance*}.
\end{itemize}
In fact, the core macros are much more powerful. \istroot controls the direction to which a simple parent-child tree grows, node styles, the node owner and its position, the height and sibling distance of a current simple tree, etc. \istb specifies the growing direction of an individual branch, branch line styles, branch color, action labels, and payoffs and their position. Below we will see in more details on how the core macros and others work.

3 The \istgame environment and node styles

3.1 The \istgame environment

The package provides the \istgame environment, which is basically the sum of the \tikzpicture environment plus some additional functions and different initial values. So it accepts all the options and macros that can be used for the \tikzpicture environment. (Note that most of the macros provided by the package work also in the \tikzpicture environment, but some works only in the \istgame environment.)

```
% \istgame environment
% \def\istgame@default@fontsize{\normalsize}
\begin{istgame}[ <Tikz options> ]
  < istgame contents >
\end{istgame}
% default options:
[ font=\normalsize , >=stealth ]
```

The default font size is set as font=\normalsize. You can globally change the default font size by using \setistgamefontsize, like \setistgamefontsize{\scriptsize}. Since the environment \istgame is basically the same as \tikzpicture, you can also locally change the font size by using the font option key, like \begin{istgame}[font=\scriptsize]...\end{istgame}.

Remark: (Not for most users) What the \istgame environment internally does includes:

- In the newly designed \istgame environment, it internally checks and extracts the optional values of xscale and yscale and, if exist, saves the values (1.0 by default) at \xtxscale and \xtyscale, respectively. And If the optional value of scale exists, it is saved at \xtscale only when neither xscale nor yscale exists. You can use these values to calculate something you want, like 5*1/\xtscale. The extracted values are internally used to get the best results of the shapes of bubble type information sets.
- The \istgame environment also checks if the arrow option [->] exists in the option list for the environment. If it exists the \istgame adds shorten =\(<\text{dim}>\) (by default 0pt) to the list as the first option together with [->]. You can change the default value, like \setistgameshorten{1.3pt}. (Though this is not for most users, you can see some more details, in Section 12.1.2.)

3.2 Node styles

3.2.1 Basic node styles

The \tikzstyle's of the six basic node styles are predefined.

- plain node: draws nothing (default: inner sep=1pt)
- null node: . (very small node) (default: minimum size=0.2pt)
- solid node: • (default node style) (default: minimum size=2.4pt)
- hollow node: • (default: minimum size=2.8pt)
- rectangle node: □ (defaults: inner sep=2pt, minimum size=4pt)
- ellipse node: ○ (defaults: inner sep=1.5pt, minimum size=4.8pt)
For some special cases, you may want to change some node styles, including the minimum size.
This can be done by \setist<...>NodeStyle, all of whose arguments are optional.

**syntax:**
\setistPlainNodeStyle{<inner sep dim>}{<outer sep dim>}
\setistSolidNodeStyle{<draw color>}{<min-size dim>}{<bg color>}{<opacity>}
\setistHollowNodeStyle{<draw color>}{<min-size dim>}{<bg color>}{<opacity>}
\setistRectangleNodeStyle{<draw color>}{<min-size dim>}{<bg color>}{<opacity>}
\setistEllipseNodeStyle{<draw color>}{<min-size dim>}{<bg color>}{<opacity>}

**Examples:**

\begin{istgame}
\setistSolidNodeStyle{blue}{10pt}
\istroot(0)[solid node]\endist\end{istgame}
\begin{istgame}
\setistHollowNodeStyle{blue}{10pt}[yellow]
\istroot(0)[hollow node]\endist\end{istgame}
\begin{istgame}
\setistRectangleNodeStyle{10pt}[red][.5]
\istroot(0)[rectangle node]\endist\end{istgame}
\begin{istgame}
\setistEllipseNodeStyle{blue}{10pt}[green]
\istroot(0)[ellipse node]\endist\end{istgame}
\begin{istgame}
\setistNullNodeStyle{blue!20}{10pt}
\istroot(0)[null node]\endist\end{istgame}

These basic node styles have their aliases, for convenience, for those who are familiar with game theoretic terminology.

**\tikzset**
\tikzset{decision node/.style=solid node} % decision nodes
\tikzset{terminal node/.style=solid node} % terminal nodes
\tikzset{initial node/.style=hollow node}
\tikzset{chance node/.style=hollow node}

The set of all nodes of a game tree can be partitioned into the set of decision nodes and that of terminal nodes. You can use initial node to distinguish the root (or the initial node) of a game tree from decision nodes. You can also use chance node to represent a chance node of a game tree.

Additional convenient node aliases are also provided: box node, square node, and oval node.

**\tikzset**
\tikzset{box node/.style=rectangle node}
\tikzset{square node/.style=rectangle node}
\tikzset{oval node/.style=ellipse node}

For aliases, you can also change the node styles, like \setistDecisionNodeStyle{blue}{3pt} or \setistBoxNodeStyle{3pt}[green][.5].

### 3.2.2 Your own node styles: \setistNewNodeStyle

You can create your own node style by \setistNewNodeStyle.

**\tikzset**
% \setistNewNodeStyle
% syntax:
% \setistNewNodeStyle{<style name>}{<opt>}{<minimum size>}
% defaults:
% {<-,-circle,draw=black,fill=white,inner sep=1pt}{6mm}
The first, mandatory denoted by \{<>\}, argument is \{style name\} to be used. The second, optional, argument is \{<options>\} to determine the style of a new node, with defaults. The third, optional, argument should be \{<minimum size>\} only in dimension, which may be frequently used.

To define, for example, a circle (by default) node with the minimum size of \textit{3mm} filled with \textit{red}, you can do like this: \texttt{\setistNewNodeStyle{new node}[fill=red]{3mm}}. In fact, this is an abbreviation of the following TikZ macro:

\begin{verbatim}
\tikzset{new node/.style={
  circle , draw=black , fill=red , inner sep=1pt , minimum size=3mm }
}
\end{verbatim}

Here is an example of using \texttt{\setistNewNodeStyle}.

\begin{verbatim}
\% Example: \setistNewNodeStyle
\begin{istgame}[scale=1.5]
  \setistNewNodeStyle{new 1}
    [regular polygon,regular polygon sides=3, shape border rotate=180]
  \setistNewNodeStyle{new 2}
    [regular polygon,regular polygon sides=3]
  \setistNewNodeStyle{new 3}[star]
  \xtdistance{15mm}{30mm}
  \istroot(0)[new 1]<center>{I}
  \istb \istb \endist
  \xtdistance{15mm}{15mm}
  \istrootto(1)(0-1)[new 2]{II} \% \istrootto
  \istb \istb \endist
  \istrootto(2)(0-2)[new 3]<center>{III}
  \istb \istb \endist
\end{istgame}
\end{verbatim}

\textbf{Remark:} From the above example, observe that when you use \texttt{\istroot} to put the owner of a node, you need to specify \texttt{<center>} for the position of the node owner. However, if you use the oval version \texttt{\istrootto}, you don’t need that. (About \texttt{\istroot} and \texttt{\istrootto}, see Section 4.)

\textbf{Remark:} In TikZ, the shape of a node is independent of the \texttt{scale} option in \texttt{tikzpicture}. If you want to make the shape scaled according to the \texttt{scale} option, you can use the TikZ option \texttt{transform shape}, as shown below. (In this kind of case, \texttt{\istrootto} helps, rather than \texttt{\istroot}.)

\begin{verbatim}
\% Example: \setistrNewNodeStyle (scaled)
\begin{istgame}[scale=1.5]
  \setistrNewNodeStyle{new 1}
    [regular polygon,regular polygon sides=3, shape border rotate=180]
  \setistrNewNodeStyle{new 2}
    [regular polygon,regular polygon sides=3]
  \setistrNewNodeStyle{new 3}[star]
  \xtdistance{15mm}{30mm}
  \istroot(0)
    [new 1,transform shape]<center>{I}
  \istb \istb \endist
  \xtdistance{15mm}{15mm}
  \istrootto(1)(0-1)[new 2]{II} \% \istrootto
  \istb \istb \endist
  \istrootto(2)(0-2)
    [new 3,transform shape]<center>{III}
  \istb \istb \endist
\end{istgame}
\end{verbatim}
4 Core macro: \istroot

4.1 \istroot: basics

4.1.1 \istroot – counterclockwise: standard version

The macro \istroot defines the root of a game or a subgame at a designated location, specifies the owner of the root or the subroot, and does other functions. In game theoretic terminology, \istroot designates a decision node and its owner (or a player).

% \istroot
% syntax:
\istroot[<grow keyval>,<tree opt>](<coor1>)(<coor2>)
[<node style>,<node opt>][<owner opt>owner label angle>{<owner>}
+<lev-distance>..<sib-distance>+
% defaults:
[south](<m>)(0,0)[decision node]<above>{}+15mm..15mm+
% arguments:
[<grow> % the direction of growing <default: south]
(coor1) % name of the (sub)root: mandatory
(coor2) % the (sub)root is at (coor2) <default: (0,0)>
[node style] % node style <default: decision node>
<angle> % position of owner name <default: above>
{owner} % name of the owner of the (sub)root
+level dist..sibling dist+ % <defaults: 15mm,15mm>

the root

The only mandatory argument, denoted by <m>, of \istroot is (coor1), which gives the name of the root or subroot. All the other arguments are optional. The name of the (sub)root, (coor1), can be referred as a normal coordinate. (coor2) specifies the location where the (sub)root is placed. If (coor2) is omitted, it is regarded as (0,0) by default.

The default node style of the root is a decision node, which is just a solid node. You can change the node style to any other node style such as initial node, chance node, oval node, box node, and so on.

Here is a simple example of drawing a tree structure.

% Example: \istroot
\begin{istgame}
\istroot(0)
 \istb \istb \istb \endist
\istroot(a)(0-1)[chance node]
 \istb \istb \endist
\end{istgame}

naming children: counterclockwise or clockwise

In the previous example, the game tree has the root named (0), located at (0,0) by default, which has three branches (by three \istb's). Since Ti\LaTeX{}Z arranges branches of a tree counterclockwise, by default, the endpoints of the three branches are automatically named (0-1), (0-2), and (0-3) from left to right (when a tree grows down).

The root of the subtree is named (a), located at (0-1), and has two children. Its children are automatically named (a-1) and (a-2) counterclockwise (or from left to right if the tree grows down). See the following code example with explanatory labels to see what is going on.
owner (or player)

The owner of a decision node (or a player) is expressed in curly braces, like \{player 1\}, and printed in text mode. The input mode and text font style of an owner can be changed by \setistmathTF(*)
(see Section 7 on page 36, for more details).

The position of the owner of a decision node is specified in angle brackets, like <90>, <above>, or <north>. To specify the position of an owner you can use \degrees, or the compass directions such as <north>, <south>, <east>, <west>, and their valid combinations. You can also use the positional words such as <above>, <below>, <left>, <right>, and their valid combinations.

growing direction of a simple tree

The first bracket option is mainly for the direction of a simple tree (south by default). Internally, \[<grow keyval>] typed in as the first option of \istroot renews the direction of tree growing by assigning its value to \istgrowdirection, whose default is south.

Remark:
• In fact, the first option of \istroot controls the features of an whole simple tree (but a node style), while the second bracket option controls a node style only.
• In addition to the direction of a simple tree, you can add more options to control the whole branch styles and their labels (except a node style). For example, if you want, at any reason, to draw a simple tree with all red dashes branches with red labels growing south-eastwards, you can do like [south east, red, dashed]. (For examples in more detail, see Section 6.1.2 on page 27.)
• Be aware that the first entry in the option list must be a directional word for a simple tree.

The tree growing direction can be specified by \[<degrees>] or by using the compass directions such as [north], [south], [east], [west], [north east], [north west], [south east], [south west]. You can also use positional words like [left], [right], [down], and [up], but you cannot use [above] nor [below].
Remark: One thing you should remember about this is that `\istgrowdirection` is internally used in the definition of `\istb` to control the label position for payoffs. However, for the label position in TiKZ, `[below]` and `[above]` are good, but not `[down]` nor `[up]`. So DO NOT USE `[down]` nor `[up]` to specify the tree growing direction.

```
\begin{istgame}
\vspace{20mm}
\istroot\[right\](0)
\istb \istb \istb \endist
\istroot(a)(0-1)[oval node]<left>{player 1}
\istb \istb \endist
\istroot\[right\](b)(0-2)[box node]<135>{player 3}
\istb \istb \endist
\end{istgame}
```

local change of distances

The last two options of `\istroot` specify the level distance and the sibling distance. This local change of distances is valid only for the corresponding simple tree, while the distances changed by `\xtdistance` are valid within the current `istgame` environment unless they are changed again by `\xtdistance`. Do not forget, when you use decimal distances, to delimit the decimal dimensions with curly braces, like `{15.5mm}`.

4.1.2 `\istroot'` — clockwise: swap version

The macro `\istroot'` is the swap version of `\istroot`. `\istroot` works just like `\istroot` but with one exception: going clockwise instead of counterclockwise. `\istroot'` arranges its branches clockwise (or from right to left if the tree grows down).

Compare the following example with that of `\istroot` above on page 15. The two examples have exactly the same codes as each other except for one thing: either `\istroot` or `\istroot'`.

```
\begin{istgame}[font=\scriptsize]
\vspace{20mm}
\istroot'(0)
\istb \istb \istb \endist
\istroot'(a)(0-1)
\istb \istb \endist
% labels: (ignore the following lines at the moment)
\setistmathTF000
\xtOwner(0){(0)}
\xtOwner(a){(a)}[1]
\xtPayoff*(0-1){(0-1)}[r]
\xtPayoff*(0-2){(0-2)}[b]
\xtPayoff*(0-3){(0-3)}[b]
\xtPayoff*(a-1){(a-1)}[b]
\xtPayoff*(a-2){(a-2)}[b]
\draw [<-,,ultra thick,blue!20](-260:1.5) arc (-260:80:1.5cm)
\node [above,blue!30] {clockwise};
\end{istgame}
```

We will look into this issue (of going counterclockwise or clockwise) in more detail in Section 9 (on page 41), where we discuss the tree growing direction.

If you draw a game tree growing south, you don’t need to worry about the swap version `\istroot'`. Just use `\istroot`.
4.2 \texttt{\istrooto}: oval version

4.2.1 \texttt{\istrooto} – counterclockwise

The macro \texttt{\istrooto} is the oval version of \texttt{\istroot}. This allows us to draw a bubble (by default, \texttt{oval node}) with a node owner (or a game player) in it. Except for this difference, \texttt{\istrooto} works just like \texttt{\istroot}. Since an owner is shown in a specified node with \texttt{\istrooto}, the option \texttt{<owner label angle>} of the standard version \texttt{\istroot} is ignored.

\begin{verbatim}
\% \istrooto
\% syntax:
\istrooto[<grow keyval.tree opt>]{<coor1>}{<coor2>}
[<node style>,<node opt>]{<owner>}+<lev-distance>..<sib-distance>+
\% default: only (coor1) is mandatory, <m>, all others optional
[<south>{<m>}{0,0}[oval node]{}+15mm..15mm]+
\end{verbatim}

The following two examples are the same as above with \texttt{\istroot} on pages 15 and 16, respectively, but now with the oval version \texttt{\istrooto}.

\begin{verbatim}
\% Example 1: \istrooto (one simple tree)
\begin{istgame}{font=\itshape}
\istrooto[right](0)<180>{player 1}
\end{istgame} \hspace{1cm} \textbf{player 1}
\end{verbatim}

\begin{verbatim}
\% Example 2: \istrooto (three simple trees connected)
\begin{istgame}
\xtdistance{20mm}{20mm}
\istrooto[right](0)[oval node]<left>{player 1}
\xtdistance{20mm}{20mm}
\istrooto(a)(0-1)<right>{player 2}+15mm..10mm+
\istrooto(b)(0-2)[box node]<135>{player 3}
\end{istgame} \hspace{1cm} \textbf{player 1}
\hspace{1cm} \textbf{player 2}
\hspace{1cm} \textbf{player 3}
\end{verbatim}

Observe that the angle \texttt{<180>, <left>, <right>, or <135> specifying the position of an owner’s name is redundant to \istrooto.}

\begin{verbatim}
\% Example 3: \istrooto (counterclockwise)
\begin{istgame}
\setistOvalNodeStyle{.6cm}
\istrooto(0){0}+{12.5mm}..{3.45cm}+
\istb \endist
\xtShowEndPoints[oval node]
\istrooto(1)(0-1){1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istrooto(2)(0-2){2}
\istb{}{6}[center] \istb{}{7}[center]
\istb{}{8}[center] \endist
\istrooto(6)(2-1){6}
\istb{}{9}[center] \istb{}{10}[center]
\endist
\draw[->,ultra thick,blue!20](-260:1.5)\arc(-260:80:1.5cm)
\node[above,blue!30] {counterclockwise};
\end{istgame}
\end{verbatim}
The previous example shows how \texttt{\textbackslash istroot} arranges its branches: \textit{counterclockwise}, by default.

### 4.2.2 \texttt{\textbackslash istroot'} – clockwise: swap version

The swap version of the oval version, \texttt{\textbackslash istroot'}, works just like \texttt{\textbackslash istroot} with one exception that it puts an owner within an \textit{oval node}, by default.

\begin{verbatim}
\texttt{ Example 2: \textbackslash istroot'} (clockwise)
\begin{istgame}
\xtdistance\{20mm\}\{20mm\}
\istroot'\{right\}\{0\}\{oval node\}<left>|\{player 1\}
\\istb \\\istb \\endist
\istroot'\{right\}\{b\}\{0-1\}\{box node\}<135>|\{player 2\}
\\istb \\\istb \\endist
\istroot\{a\}\{0-2\}<right>|\{player 3\}+15mm..10mm+
\\istb \\\istb \\endist
\\end{istgame} \\
\end{verbatim}

The swap version is useful when a tree grows northwards or eastwards. The example below shows a tree rotated to the east by \texttt{\setistgrowdirection}. Note that \texttt{\textbackslash istroot'} arranges its branches \textit{clockwise}.

\begin{verbatim}
\texttt{ Example 3: \textbackslash istroot'} (clockwise)
\begin{istgame}
\setistgrowdirection\{east\}
\setistOvalNodeStyle\{.6cm\}
\istroot\{0\}\{0\}<\{12.5mm\}..\{3.45cm\}+
\\istb \\\istb \\endist
\xtShowEndPoints[oval node]
\xtdistance\{12.5mm\}\{11.5mm\}
\istroot\{1\}\{0-1\}<1
\\istb\{3\}[center] \\\istb\{4\}[center]
\\istb\{5\}[center] \\endist
\istroot\{2\}\{0-2\}<2
\\istb\{6\}[center] \\\istb\{7\}[center]
\\istb\{8\}[center] \\endist
\istroot\{6\}\{2-1\}<6
\\istb\{9\}[center] \\\istb\{10\}[center]
\\endist
\draw [\text{-},ultra thick,blue!20] (260:1.5)
\arc (260:-80:1.5cm)
\node [below,blue!30] {clockwise};
\end{istgame}
\end{verbatim}

\textbf{Remark:} When you use the swap version \texttt{\setistgrowdirection'}, using either \texttt{\textbackslash istroot} or \texttt{\textbackslash istroot'} makes no difference. (For more details, see Section 9 on page 41.)

### 5 Core macro: \texttt{\textbackslash istb}

#### 5.1 \texttt{\textbackslash istb}: basics

\textbf{5.1.1 Basics: branches, action labels, and payoffs}

The macro \texttt{\textbackslash istb}, basically, prints a branch. Having all arguments as options, a simple \texttt{\textbackslash istb} draws a branch from a parent node designated by \texttt{\textbackslash istroot} to a child node (or endpoint of \texttt{\textbackslash istb}). If, for example, a parent node is named \texttt{(A)} by \texttt{\textbackslash istroot}, the first child node is automatically named \texttt{(A-1)}, the second child node \texttt{(A-2)}, and so on.
The macro \texttt{\istb} also puts an \textit{action} label and \textit{payoffs} along with a branch, and does other functions. Note that the \textit{action labels} and \textit{payoffs} are to be typeset in \textit{math mode}. If you want to change the input mode to text mode, you can use the macro \texttt{\setistmathTF(*)}. This issue is discussed in Section 5.1.2 below. (You can also see Section 7, on page 36, for more details).

\begin{verbatim}
% \istb
% syntax:
\istb\{grow, distance, missing\}\{<line style>\}\{<action>\}\{<pos>\}\{<payoff>\}\{<pos>\}
% defaults:
<grow=south>{-}{}[center]{}[\istgrowdirection]
% arguments: all arguments are optional
<grow=keyval> % the direction of a branch <default: south>
[line style] % branch line style <default: solid>
{action} % action label (in math mode)
{action pos} % position of action label <default: center>
{payoff} % payoffs (in math mode)
{payoff pos} % position of payoffs <default: \istgrowingdirection: south>
\end{verbatim}

Remark: The macro \texttt{\istb} has many variants including \texttt{\istb*} (starred version), \texttt{\istbt} (terminal version), and \texttt{\istbm} (missing version). It also has other very close friends: \texttt{\istB} (dual label version) and \texttt{\istbA} (alternative or arc version). Each friend of \texttt{\istb} has its starred version and terminal version, of course, except \texttt{\istbm}. \texttt{\cntmistb(*)} and \texttt{\cntmAistb(*)} are also friends only when a continuum of branches is in play.

\textbf{branches}

In the example below, each \texttt{\istb} draws a branch. With the option \texttt{missing}, \texttt{\istb} prints an \textit{invisible} branch. Since the third child is \textit{missing}, the last child is named (0-4).

\begin{verbatim}
\begin{istgame}
\istroot(0)
\istb \istb \istb<missing> \istb \endist
\istroot(D)(0-4)
\istb \istb \endist
\end{istgame}
\end{verbatim}

To make it simple, you can use the \textit{missing version} \texttt{\istbm} instead of \texttt{\istb<missing>}. The macro \texttt{\istb} also has various options to control the line style of a branch, and the direction and length of a branch. \texttt{\istb} can also place payoffs to the direction of tree growth by default. For various line styles of each branch, you can use any TikZ options of arrows, line style, color, and so on.

\begin{verbatim}
\begin{istgame}
\istroot(0)
\istb[dashed,thick]
\istb[-]
\istb[draw=blue,thick]
\endist
\end{istgame}
\end{verbatim}
action labels

By default, an action label is put on the midpoint of the corresponding branch, in \textit{math} mode.

\begin{verbatim}
\begin{tikzpicture}
  \node (Root) {$\ast$};
  \node (Left) at (0, -1) {$\ast$};
  \node (Center) at (0, 0) {$\ast$};
  \node (Right) at (0, 1) {$\ast$};
  \draw[->, dashed, thick] (Root) -- (Left);
  \draw[->, dashed, thick] (Root) -- (Center);
  \draw[->, dashed, thick] (Root) -- (Right);
\end{tikzpicture}
\end{verbatim}

To specify the position of an action label, you can use the positional words or their abbreviations: [a] for [above], [b] for [below], [l] for [left], [r] for [right], [al] for [above left], [ar] for [above right], [bl] for [below left], and [br] for [below right].

\textbf{Remark:} Note that these abbreviations must be used with no other options, otherwise you will get a compile error. For example, when you want to print sloped labels for actions, you should do like [above, sloped] but not like [a, sloped].

\begin{verbatim}
\begin{tikzpicture}
  \node (Root) {$\ast$};
  \node (Left) at (0, -1) {$\ast$};
  \node (Center) at (0, 0) {$\ast$};
  \node (Right) at (0, 1) {$\ast$};
  \draw[->, dashed, thick] (Root) -- (Left)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Center)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Right)[above,sloped];
\end{tikzpicture}
\end{verbatim}

\textbf{Warning:} Issues in sloped labels in TikZ with asymmetric scales:

- The \texttt{tree} library in TikZ does not seem to treat sloped labels properly, when \texttt{xscale} or \texttt{yscale} is used asymmetrically.

\begin{verbatim}
\begin{tikzpicture}
  \node (Root) {$\ast$};
  \node (Left) at (0, -1) {$\ast$};
  \node (Center) at (0, 0) {$\ast$};
  \node (Right) at (0, 1) {$\ast$};
  \draw[->, dashed, thick] (Root) -- (Left)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Center)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Right)[above,sloped];
\end{tikzpicture}
\end{verbatim}

- This package provides a temporary solution to cure this issue: \texttt{xtcureslopedlabelsNS} for trees growing northwards or southwards. If a tree grows eastwards or westwards, then use \texttt{xtcureslopedlabelsEW}. These must be used in a TeX group with caution. These are only temporary solutions that have not been tested for every occasion.

\begin{verbatim}
\begin{tikzpicture}
  \node (Root) {$\ast$};
  \node (Left) at (0, -1) {$\ast$};
  \node (Center) at (0, 0) {$\ast$};
  \node (Right) at (0, 1) {$\ast$};
  \draw[->, dashed, thick] (Root) -- (Left)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Center)[above,sloped];
  \draw[->, dashed, thick] (Root) -- (Right)[above,sloped];
\end{tikzpicture}
\end{verbatim}
payoffs

The second curly braces option of the macro \istb is for payoffs and the last bracket option for the position of payoffs.

By default, \istb prints payoffs in math mode, which can be changed by \setistmathTF(*).

By default, payoffs are put in the direction of \istgrowdirection ([south] by default).

% Example: payoffs
\begin{istgame}
\istroot(0)
\istb[dashed,thick]{A}{(0,1)}
\istb[->]{{(1,-1)}}
\istb[draw=blue,thick]{{\beta}[a]{u_1,u_2}}
\endist
\end{istgame}

Remark: What is \istgrowdirection and what is it used for?

- \istgrowdirection has the value of [\texttt{<grow keyval>}] typed in \istroot (default: south).
- The value of \istgrowdirection is (internally) used to determine the direction of putting payoffs (south by default).

In the following example, notice that the tree grows south-eastwards, so the payoffs are placed to the south-east of the endpoints.

% Example: tree toward south east (or -45 degree)
\begin{istgame}
\istroot[-45](0)
\istb[dashed,thick]{A}{(0,1)}
\istb[->]{{(1,-1)}}
\istb[draw=blue,thick]{{\beta}[a]{u_1,u_2}}
\endist
\end{istgame}

If you do not like the position of payoffs, you can change it by using degrees, the compass directions, or the positional words and their abbreviations mentioned above. In the example below, the tree grows south-westwards, but the position of payoffs at the end of the blue branch is changed to [below] or [b].

% Example: tree toward south west (or 225 degree)
\begin{istgame}
\istroot[south west](0)
\istb[dashed,thick]{A}{(0,1)}
\istb[->]{{(1,-1)}}
\istb[draw=blue,thick]{{\beta}[r]{u_1,u_2}[below]}
\endist
\end{istgame}

Remark:

- \istb expects a directional word to be input as the last optional argument (by default, \istgrowdirection).
- You can add more options to change the position of payoffs, but the first entry of the option list must be a directional word, like [\texttt{below,xshift=5mm}], but not like [\texttt{xshift=5mm,below}]. Otherwise, a compile error will be produced.
- Note also that you can do like [[\texttt{xshift=5mm}below], instead (see also page 41).
5.1.2 Printing action labels in italics in text mode: \texttt{\setistmathTF*}

By default, an owner is printed in \textit{text mode}, action labels and payoffs in \textit{math mode}. With the macro \texttt{\setistmathTF(*)}, you can change the input mode for those labels. These are discussed in Section 7 on page 36.

Here, it is briefly discussed how to change the input mode of action labels to \textit{text mode}. To do that, just declare \texttt{\setistmathTF001}. The second zero means that the input mode for action labels is in text mode. (The first number is for owners and the third one for payoffs.)

\begin{verbatim}
\begin{istgame}[font=\footnotesize]
\setistmathTF001
\istroot(0)
  \istb[dashed,thick]{\textit{Left}}[above,sloped]{(0,1)}
  \istb[-]{\textit{Center}}[above,sloped]{(1,-1)}
  \istb[draw=blue,thick]{\textit{Right}}[above,sloped]{u_1,u_2}
\end{istgame}
\end{verbatim}

If you use the starred version, like \texttt{\setistmathTF*001}, action labels are printed in \textit{italics}, by default.

\begin{verbatim}
\begin{istgame}[font=\footnotesize]
\setistmathTF*001
\istroot(0)
  \istb[dashed,thick]{\textit{Left}}[above,sloped]{(0,1)}
  \istb[-]{\textit{Center}}[above,sloped]{(1,-1)}
  \istb[draw=blue,thick]{\textit{Right}}[above,sloped]{u_1,u_2}
\end{istgame}
\end{verbatim}

You can, of course, do the same thing in the default math mode.

\begin{verbatim}
\begin{istgame}[font=\footnotesize]
%\setistmathTF011 (default modes)
\istroot(0)
  \istb[dashed,thick]{\textit{Left}}[above,sloped]{(0,1)}
  \istb[-]{\textit{Center}}[above,sloped]{(1,-1)}
  \istb[draw=blue,thick]{\textit{Right}}[above,sloped]{u_1,u_2}
\end{istgame}
\end{verbatim}

5.2 \texttt{\istb*}: starred version

5.2.1 \texttt{\istb*}: basics

The starred version \texttt{\istb*} prints a \textit{solid node} at the end of the corresponding branch. This is the only difference between \texttt{\istb} and \texttt{\istb*}.

\begin{verbatim}
\begin{istgame}
\istroot[east](0)
  \istb[dashed,thick]{A}
  \istb*[-]{(1,-1)}
  \istb*[draw=blue,thick]{\beta}[a]
\end{istgame}
\end{verbatim}
5.2.2 \texttt{\xtShowEndPoints} and \texttt{\xtHideEndPoints}

Each endpoint is printed by each execution of \texttt{\istb*}. You can print solid nodes (by default) at all the endpoints of simple trees by the macro \texttt{\xtShowEndPoints}. You can also change the style of nodes for all the endpoints of simple trees, by specifying it as an optional argument, like \texttt{\xtShowEndPoints[oval node]}.

\begin{verbatim}
\% \xtShowEndPoints
\% syntax:
\xtShowEndPoints[<node style>]
\% default:
[solid node]
\end{verbatim}

The macro \texttt{\xtHideEndPoints} turns off the effects of \texttt{\xtShowEndPoints}.

It is too early to say that the starred version \texttt{\xtShowEndPoints*} additionally prints the two outermost endpoints of a continuum. \texttt{\xtHideEndPoints*} turns off only the outermost endpoints a continuum, but not the other endpoints. (See Section 11.4.3 on page 67, for more details.)

Here is an example of using \texttt{\xtShowEndPoints} and \texttt{\xtHideEndPoints}.

\begin{verbatim}
\begin{istgame}
\xtShowEndPoints[oval node,minimum size=6pt]
\istroot(0)[solid node]
\istb[dashed,thick]{A}
\istb
\istb[very thick]{\beta}[ar]
\endist
\xtShowEndPoints % default: solid nodes
\xtdistance{15mm}{10mm}
\istroot(b)(0-2) \istb \istb \endist
\xtHideEndPoints % \istb* overrides
\istroot(b)(0-3) \istb \istb* \endist
\end{istgame}
\end{verbatim}

Note that \texttt{\xtShowEndPoints} and \texttt{\xtHideEndPoints} should be in an \texttt{istgame} environment to avoid unexpected results. Note also that \texttt{\istb*} overrides all the effects of these two macros by forcing to print a solid node.

5.3 \texttt{\istbt}: terminal version

5.3.1 \texttt{\istbt}: basics

The terminal version \texttt{\istbt} is designed to represent a terminal move in a game tree. Basically, \texttt{\istbt} works exactly the same way as \texttt{\istb} does. However, using \texttt{\istbt} together with the macro \texttt{\xtShowTerminalNodes} you can control the shape of the terminal nodes, all at once.

5.3.2 \texttt{\xtShowTerminalNodes} and \texttt{\xtHideTerminalNodes}

The terminal version \texttt{\istbt} used with \texttt{\xtShowTerminalNodes} prints a solid node (by default). You can change the style of the terminal nodes, like \texttt{\xtShowTerminalNodes[oval node]}. This effect can be turned off by \texttt{\xtHideTerminalNodes}.

\begin{verbatim}
\% \xtShowTerminalNodes (works only with \istbt and other terminal versions)
\% syntax:
\xtShowTerminalNodes[<node style>]
\% default:
[solid node]
\end{verbatim}
Remark: Note that controlling terminal nodes by using `\xtShowTerminalNodes` works only with the terminal versions `\istbt`, `\istBt` (documented below in Section 5.4) and `\istbt*` (in Section 5.5), but there will be no effect and no harm with other versions. Note also that `\istbt*` overrides the effects of `\xtShowTerminalNodes` and `\xtHideTerminalNodes`.

5.4 `\istB`: dual label version

5.4.1 `\istB`: basics

The macro `\istB` works just like `\istb`, except one thing: `\istB` prints dual labels for a branch. The starred version `\istB*` prints a solid node at the end of the corresponding branch, just like `\istb*`. And the terminal versions `\istBt` and `\istBt*` work just like `\istbt` and `\istbt*`, respectively, except for dual labels.

With `\istB`, do not forget to put two labels. Otherwise, you might get an unexpected result.
5.4.2 \texttt{\texttt{\textbackslash{}xtActionLabel} and \texttt{\textbackslash{}xtActionLabel*}}

You can also use the supplementary macro \texttt{\textbackslash{}xtActionLabel} to print additional action labels (see also Section 12.2 on page 73). The macro \texttt{\textbackslash{}xtActionLabel} controls, from outside of a simple tree, a branch (by default \texttt{draw=none}) with a label (in math mode by default), connecting two nodes.

\begin{verbatim}
\% \texttt{\textbackslash{}xtActionLabel} syntax:
\texttt{\textbackslash{}xtActionLabel*}[<\texttt{line opt}>][(<\texttt{from}>)][(<\texttt{to}>)][<\texttt{action}>][<\texttt{pos}>,<\texttt{node opt}>]
\% default:
[-,draw=none](<m>)(<m>){}
black,text depth=.25
\end{verbatim}

**Remark:** In some cases, it is not a good idea to use \texttt{\texttt{\textbackslash{}istB}} to print dual action labels.

- With \texttt{\texttt{\textbackslash{}istB}}, the features of *middle arrows* provided by this package does not work well (see Section 12.2 on page 73).
- With respect to a *continuum* of branches, \texttt{\texttt{\textbackslash{}istB}} has little role to play.

You can do the same thing as \texttt{\texttt{\textbackslash{}istB}} does by using \texttt{\texttt{\textbackslash{}istb}} and together with \texttt{\texttt{\textbackslash{}xtActionLabel}}.

\begin{verbatim}
\% Example: \texttt{\texttt{\textbackslash{}istb} and \texttt{\textbackslash{}xtActionLabel}}
\begin{istgame}[font=\footnotesize]
\xtdistance{15mm}{30mm}
\istroot(0)[chance node]
\istb{Left}{al}
\istb{Right}{ar}
\endist
\istroot(1)(0-1)[initial node]
\istbt{Head}{al}
\istbt{Tail}{ar}
\endist
\xtActionLabel(0)(0-1){x}[br]
\xtActionLabel(0)(0-2){1-x}[bl]
\xtActionLabel(1)(1-1){y}[br]
\xtActionLabel*[draw,blue,thick](1)(1-2){1-y}[bl]
\end{istgame}
\end{verbatim}

The starred version \texttt{\texttt{\textbackslash{}xtActionLabel*}} prints its label in the input mode as set by \texttt{\texttt{\setistmathTF*}} (see Section 7 on page 36, for more details on \texttt{\setistmathTF}).
5.5 \texttt{\textbackslash istbA}: alternative (or arc) version

5.5.1 \texttt{\textbackslash istbA}: basics

The macro \texttt{\textbackslash istbA} is an alternative (or arc) version, doing one more thing than \texttt{\textbackslash istb}. With \texttt{\textbackslash istbA} you can \textit{easily change the level distance} of an individual branch using a factor (1, by default) \textit{as the first optional argument} in parentheses. All other arguments are the same as in \texttt{\textbackslash istb}. For example, \texttt{\textbackslash istbA(.5)} is an abbreviation of \texttt{\textbackslash istb<level distance=.5*xtlevdist>}, as you can see in the example below:

\begin{verbatim}
\% Example: \texttt{\textbackslash istbA}
\begin{istgame}
 \istroot(0) \ istb \ istbA \endist
 \istroot(1)(0-1) \ istb \ istbA(.5){b} \endist
 \istroot(2)(0-2) \ istb
 \istbA<level distance=.5*xtlevdist>{b} \endist
\end{istgame}
\end{verbatim}

You can interchangeably use \texttt{\textbackslash istbA} and \texttt{\textbackslash istb}, except for one case, in which you are working with a continuum of branches.

Remark: (too early to comment)

- The macro \texttt{\textbackslash istbA} is originally created to work with \texttt{\textbackslash istrootcntmA} as an arc version.
- \texttt{\textbackslash istbA} draws, by default, a branch up to an arc when used with the continuum arc version \texttt{\textbackslash istrootcntmA}, but \texttt{\textbackslash istb} does not. (For more details, see Section 11.2.1 on page 61.)
- Except for the case of using a continuum of branches, \texttt{\textbackslash istbA} is equivalent to \texttt{\textbackslash istb} for users.

Its terminal version \texttt{\textbackslash istbAt} is also available, but the dual label version of \texttt{\textbackslash istbA} is not provided. The starred versions \texttt{\textbackslash istbA*} and \texttt{\textbackslash istbAt*} print an solid node (by default) at the end of the corresponding branch.

5.5.2 \texttt{\textbackslash istbA}: application

By specifying the \texttt{grow} key of \texttt{\textbackslash istb} you can draw a branch with the exact length you want.

\begin{verbatim}
\% Example: \texttt{\textbackslash istbA}
\begin{istgame}
 \xtdistance{10mm}{15mm}
 \istroot(0) \ istb \ istb \ istbA \ istbA .7{grow=-120} % 7mm long
 \ istbA \ istbA{grow=-30}{b} % 10mm long
 \endist
 \istroot(2)(0-3) \ istb \ istbA{b} \endist
 \draw[dashed] (1) circle (10mm);
 \draw[dotted] (1) circle (7mm);
\end{istgame}
\end{verbatim}

You can also apply \texttt{\textbackslash istbA} to easily ruin your regular balanced trees.

\begin{verbatim}
\% Example: \texttt{\textbackslash istbA}
\begin{istgame}
 \xtdistance{10mm}{15mm}
 \istroot(0) \ istbA(.2) \ istbA(1.5) \ istbA{1.2} \endist
 \istroot(1)(0-1)
 \ istbA{.7} \ istb \ istbA(2){grow=-60}{b} \endist
 \istroot(2)(0-3) \ istbA{.2} \ istbA{-1}{b} \endist
\end{istgame}
\end{verbatim}
6 Important labels: players, action labels, and payoffs

6.1 How to put players

6.1.1 Players: basics

The macro `\istroot` specifies the (sub)root of a simple tree and puts its owner (or a player). The direction to which a player label is put is set by the angle `< >` option of `\istroot`, like `<above>` (by default), `<east>`, or `<45>`. To specify the direction you can use degrees, the compass directions, or positional words.

```latex
% Example: node owner
\begin{istgame}
\istroot(0)<above>{Child} % default: <above>
\istb \istb \endist
\istroot(1)(0-2)<45>{\textbf{Parent}}
\istb \istb \endist
\end{istgame}
```

Remark:

- The supplementary macro `\xtOwner` is provided as an extra way of putting owners of decision nodes (see Section 13.1 on page 78).
- Though an owner is to be input in text mode, by default, it is also possible to change the input mode to math mode with `\setistmathTF(*)` (see below in Section 6.1.4 and Section 7 on page 36).

Note that the oval version `\istooto` produces a bubble type node with an owner in it, so the directional option `<angle>` is redundant with `\istooot` (see Section 4.2 on page 17).

```latex
% Example: node owner (with \istooot)
\begin{istgame}
\istooot(0){Child}
\istb \istb \endist
\istooot(1)(0-2)<45>{\textbf{Parent}}
\istb \istb \endist
\end{istgame}
```

6.1.2 Coloring players or a whole simple tree using `\istroot`

You can change the color of a player’s name by giving `color` in the angle option of `\istroot`, like `{[red]}` or `{[blue]45}`. (This is the TikZ way of giving options for a node label.)

```latex
% Example: coloring players
\begin{istgame}
\istroot(0){[red]}{Child}
\istb \istb \endist
\istroot(1)(0-2){[blue]45}{\textsf{Parent}}
\istb \istb \endist
\end{istgame}
```
The example below shows how you color a whole simple tree: red for the Child’s simple tree and blue for the Parent’s simple tree.

\begin{istgame}
\istroot[south,red](0) % whole simple tree, but node
\istb{[draw=red,fill=red]} % for node only
\istb{[red]}(Child) % for owner only
\endist
\istroot[south,draw=blue](1)(0-2)<45>{\texttt{Parent}}
\istb{[1]}(1,-1)[south]
\istb{[ar]}{1,1}[-90]
\endist
\end{istgame}

Remark:

• In the above example, the first \istroot has three bracket [option]’s: the first bracket option is for a whole simple tree including branches and labels (except a node style), the second for a a node style of a decision node, and the third for the owner of the (sub)root.
  – If you want to have all the branches, action labels, and payoffs in red, just use the color name like [south,red]. If you want to have just the branches in blue, use the draw option key like [south,draw=blue]. (This is what TikZ does.)

• Note that the first entry in the first [option] list of \istroot must be the growing direction of a simple tree. So it should be input like [south,red], but never like [red,south]. (This is what \istroot requires.) Otherwise, you will get a compile error.

6.1.3 Decorating players or a whole simple tree using \istrooto

The oval version \istrooto puts an owner within a bubble type node. With \istrooto, the color of a player can be changed by the second bracket [option], such as [red] or [blue]. (This is the TikZ way for giving options for a node.)

\begin{istgame}
\istrooto(0)[red]{Child}
\istb{[a]}(B)[below] \istb{[c]} \endist
\istrooto(1)(0-2)[blue,dashed]{Parent}
\istb \istb \endist
\end{istgame}

The following example shows how you can color, with \istrooto, a whole simple tree including action labels and payoffs in red or blue, except for node styles.

\begin{istgame}
\istrooto[south,red](0)[draw=green,blue]{Child}
\istb{[a]}(B)[below] \istb{[c]} \endist
\istrooto[-90,blue](1)(0-2)[draw=blue,blue]{Parent}
\istb* \istb \endist
\end{istgame}

What if you want to paint some color into the background of each oval node or box node? You can also do this simply by using the TikZ way of giving options for nodes.
6.1.4 Changing the input mode and text font style: \setistmathTF(*)

You can change the input mode for owners from text mode (by default) to math mode by using the macro \setistmathTF111 which has three mandatory arguments. The first number 1 means that an owner is printed in \textit{math mode}. (The second number 1 and third number 1 mean that action labels and payoffs are in \textit{math mode}, respectively.) \setistmath011 means that an owner is printed in \textit{text mode} (this is default).

\begin{verbatim}
\setistmathTF\begin{istgame}
\istroot(0){\Omega_{\alpha}}+10mm..20mm+
\istb \istb \endist
\setistmathTF111 \setistmathTF011 \setistmathTF*011<texttt>
\istroot(1){(0-1)<180}>{\alpha}_1 \istb \istb \endist
\istroot(2){(0-2)<0}>{\alpha}_2 \istb \istb \endist
\setistmathTF\end{istgame}
\end{verbatim}

The starred version, for example, \setistmathTF*011, enables you to change the font style of an owner. Moreover, by specifying a text font style, like \setistmathTF*011<texttt>, in angle brackets, you can print an owner in typewriter font. (See Section 7 on page 36, for more details.)

The supplementary macro \xtOwner gives an alternative way of putting, outside of a simple tree, an owner in \textit{text mode} at a node. The starred version \xtOwner* prints an owner as in the input mode set by \setistmathTF*. (See Section 13.1 on page 78, for more details on \xtOwner.)

\begin{verbatim}
\setistmathTF*\begin{istgame}
\setistmathTF111 \setistmathTF011 \setistmathTF*011<texttt>
\istroot(0){\Omega_{\alpha}}+10mm..20mm+
\istb \istb \endist
\setistmathTF011 \setistmathTF*011<texttt>
\istroot(1){(0-1)<180}>{\alpha}_1 \istb \istb \endist
\istroot(2){(0-2)<0}>{\alpha}_2 \istb \istb \endist
\xtOwner*(1)\{\alpha}_1 \istb \istb \endist
\xtOwner*(2)\{\alpha}_2 \istb \istb \endist
\xtOwner*\end{istgame}
\end{verbatim}
6.2 How to put action labels

6.2.1 Action labels: basics

The macro \istb prints a branch and its action label. Note that action labels should be input in \textit{math mode}, by default.

\begin{verbatim}
\begin{istgame}
\istroot(0)
  \istb{Good}[above left] \istb{Bad} \endist
\istroot(1)(0-2)
  \istb{\text{\fbox{$\alpha$}}}[above left]
  \istb{\text{\fbox{$\beta$}}}[above right]
\endist
\end{istgame}
\end{verbatim}

By default, \istb prints its action label on the midpoint of the corresponding branch. You can specify the position of an action label with the positional words and their abbreviations but not by the compass directions or degrees.

In the following example, the abbreviations are used to place action labels.

\begin{verbatim}
\begin{istgame}
\istroot(0)
  \istb{Good}[al] \istb{Bad} \endist
\istroot(1)(0-2)
  \istb{\text{\fbox{$\alpha$}}}[al]
  \istb{\text{\fbox{$\beta$}}}[ar]
\endist
\end{istgame}
\end{verbatim}

Notice that with the \textit{abbreviations} the position of an action label is (internally) adjusted to get better result (for more details, see Section 8.2.2 on page 40).

Remark:

- The supplementary macro \xtActionLabel is provided for an extra way of putting an action label (see Section 13.1 on page 78, for more details).
- By default, action labels are to be input in \textit{math mode}. You can change the input mode to text mode by using \texttt{\setistmathTF} or \texttt{\setistmathTF*} (see below in Section 6.2.5 and Section 7 on page 36).

6.2.2 Decorating action labels

You can change the color of action labels with TikZ options. In the example below, the bracket options before an action label are for branches and those after are only for the action labels.

\begin{verbatim}
\begin{istgame}
\istroot(0)
  \istb[dashed,thick]{A}[al]
  \istb[blue,very thick]{B}[r]
  \istb[blue,very thick]{C}[above right,red]
\endist
\end{istgame}
\end{verbatim}

Remark: It is \textit{important} to remember that you cannot use the abbreviations with additional options. For example, you can do like \texttt{\istb(C)[ar]} but not like \texttt{\istb(B)[ar,red]}. Instead, you should do like \texttt{\istb(C)[above right,red]}.
You can also express action labels in a box or a circle, or other shapes with colors.

\begin{istgame}
\istroot(0)
\istb[A]{above left,\textbf{draw}=black,\textbf{circle},\textbf{fill}=red!20}
\istb[B]{right,\textbf{draw}=black,\textbf{fill}=green,\textbf{inner sep}=0pt}
\istb{\textbf{C}}{above right,\textbf{fill}=blue,yellow}
\endist
\istroot(1)(0-2)
\istb[D]{above left,\textbf{xshift}=-3pt,\textbf{draw}=blue,\textbf{double}}
\istb[E]{above right,\textbf{xshift}=5pt,\textbf{draw},\textbf{star}}
\endist
\end{istgame}

6.2.3 Sloped action labels

You can print sloped labels for actions by using the TikZ option \texttt{sloped}. Still you should remember that you cannot use the abbreviations to place action labels with other options like \texttt{sloped}.

\begin{istgame}
\istroot(0)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\istroot(1)(0-2)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\end{istgame}

\textbf{Warning:} Issues in sloped labels in TikZ with asymmetric scales:

- The \texttt{tree} library in TikZ does not seem to treat sloped labels properly, when \texttt{xscale} or \texttt{yscale} is used asymmetrically.

\begin{istgame}[xscale=2.5]
\istroot(0)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\istroot(1)(0-2)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\end{istgame}

- A temporary solution to cure this issue is to declare the macro \texttt{\xtcureslopedlabelsNS}, provided with this package, in a TeX group with caution. For a tree growing eastwards or westwards, use \texttt{\xtcureslopedlabelsEW}, instead. (These solutions are only temporary. They have not been tested for every occasion.)

\begin{istgame}[xscale=2.5]
\xtcureslopedlabelsNS
\istroot(0)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\istroot(1)(0-2)
\istb{\text{\textbf{\fbox{$\alpha$}}}}{above,sloped}
\istb{\text{\textbf{\fbox{$\beta$}}}}{above,sloped}
\endist
\end{istgame}
6.2.4 Dual action labels

You can also express dual labels for actions by using \textbf{\texttt{\textit{istB}}} or \textbf{\texttt{\textit{istBt}}}.

You can do the same thing as \textbf{\texttt{\textit{istB}}} does by using \textbf{\texttt{\textit{istb}}} together with the supplementary macro \texttt{\textit{xtActionLabel}} (see Section 5.4.2 for more details on dual action labels).

6.2.5 Changing the input mode and text font style: \texttt{\textit{setistmathTF}}(*)

By default the input mode for action labels is in math mode. With \texttt{\textit{setistmathTF}}, you can change the input mode for labels. The package’s default input mode is set as \texttt{\textit{setistmathTF}011}, meaning that the input mode for an owner is in text mode (denoted by the first 0), for action labels in math mode (denoted by the second number 1), and for payoffs in math mode (denoted by the third number 1).

So if do like \texttt{\textit{setistmathTF}001} (with the second number 0), action labels are in text mode.

Moreover, if you use the starred version, like \texttt{\textit{setistmathTF}*001}, action labels automatically are printed in italics. If you specify a font style in curly braces, like \texttt{\textit{setistmathTF}*001\{texttt\}}, you can even print action labels in typewriter font. For more details, see Section 7 on page 36.

The supplementary macro \texttt{\textit{xtActionLabel}} prints, from outside of a simple tree, an action label in math mode. The starred version \texttt{\textit{xtActionLabel}*} prints an action label in the input mode as set by \texttt{\textit{setistmathTF}*}. For more details, see Section 5.4.2 (on page 25) and Section 7 (on page 36).
6.3 How to put payoffs

6.3.1 Payoffs: basics

The macro \texttt{\istb} can print a branch and also the corresponding payoffs, in \textit{math mode} by default, near at its endpoint. The payoffs are put in the direction set by \texttt{\setistgrowdirection (south, by default)}, unless it is changed by \texttt{<grow keyval>} of \texttt{\istroot}.

\begin{verbatim}
\% Example: payoffs
\begin{istgame}
\istroot(0) \istb[Good]{1}{0,2} \istb[Bad]
\endist
\istroot(1)(0-2) \istb[\alpha]{(1,1)} \istb[\beta]{-1,-1}
\endist
\end{istgame}
\end{verbatim}

Remark:

- The supplementary macro \texttt{\xtPayoff} is provided for an extra way of putting payoffs (see Section 13.1 on page 78).
- The payoffs are to be input in math mode, by default, you change the input mode to text mode by using \texttt{\setistmathTF(*)} (see Section 7 on page 36).

6.3.2 Payoffs and \texttt{\istgrowdirection}

The direction of where payoffs are put from a terminal node follows \texttt{\istgrowdirection} typed in as the first optional argument of \texttt{\istroot}. The default direction is \texttt{south} and can be changed by \texttt{\setistgrowdirection}. For example, \texttt{\setistgrowdirection{north}} changes the default direction to \texttt{north}.

To specify the tree growing direction or the position of payoffs to be put, you can use degrees, the compass directions, or the positional words and their \textit{abbreviations}.

\begin{verbatim}
\% Example: grow=south (default)
\begin{istgame}
\istroot(0) \istb[dashed,thick]\{\binom23\} \istb\{\beta\}[ar]\{2,3\}
\endist
\end{istgame}
\end{verbatim}

Remark:

- You can simply omit the position of payoffs. Then they are printed, by default, in the direction as set by \texttt{\istgrowdirection}.
- However, if you use options other than the direction of payoffs, you must specify the direction with others.
- Moreover, the direction \textit{must} be the first entry of the option list for payoffs and the abbreviations cannot be used. For example, \texttt{[b,yshift=-3mm] and [yshift=-3mm,below]} are not acceptable. It must be that \texttt{[below,yshift=-3mm]}.
- Note also that you can do like \texttt{[[yshift=-3mm]below}, instead (see also page 41).
You can see more examples, below, that show the positions of payoffs, by default, depend on the tree growing directions, unless you specify different directions.

\begin{istgame}
\istroot[0]
\istb[dashed,thick]{A}{\binom23}
\istb*{((-2,3))}
\istbt[blue,very thick]{B}[al]{2,3}
\endist
\end{istgame}

\begin{istgame}
\istroot[right](0)
\istb[dashed,thick]{A}{\binom23}
\istb*{((-2,3))}
\istbt[blue,very thick]{B}[al]{2,3}
\endist
\xtHideTerminalNodes
\end{istgame}

\begin{istgame}
\setistgrowdirection{north}
\istroot[0]
\istb[dashed,thick]{A}{\binom23}
\istb*{((-2,3))}
\istbt[blue,very thick]{B}[bl]{2,3}
\endist
\end{istgame}

\begin{istgame}
\istroot[south west](0)
\istb[dashed,thick]{A}{\binom23}
\istb*{((-2,3))}
\istbt[blue,very thick]{B}[right]{2,3}
\endist
\end{istgame}

You can adjust the direction of putting payoffs by specifying a directional word right after payoffs, like \istb[blue,very thick]{B}[right]{2,3}[below].

You can use the abbreviations [l], [r], [a], and [b] for [left], [right], [above], and [below], respectively. The abbreviations [al], [ar], [bl], and [br] can also be used for [above left], [above right], [below left], and [below right], respectively, to put payoffs (for more details about abbreviations, see Section 8.2.2 on page 40).

Notice also that, instead of the positional words, you can use the compass directions or degrees, like \istb[blue,very thick]{B}[right]{2,3}[-90].
6.3.3 Decorating payoffs

You can change the color of payoffs by giving \texttt{TikZ} options right before the positional words for payoffs. For example you can do like \texttt{\istb...{(1,1)}{[blue]below}}. Note that, in this case, you cannot use the abbreviation of the positional words.

\begin{verbatim}
\% Example: coloring payoffs
\begin{istgame}
 \istroot(0)
 \istb(Good)[1]{0,2} \istb(Bad) \endist
 \istroot(1)(0-2)
 \istb(\alpha)[al]{{(1,1)}\{[red]below}
 \istb(\beta)[ar]{-1,-1}\{[blue]below}
 \endist
\end{istgame}
\end{verbatim}

You can also put payoffs in a box, a circle, or other shapes, even with color in the background.

\begin{verbatim}
\% Example: decorating payoffs
\begin{istgame}
 \istroot(0)
 \istb(Good)[1]{0,2}\{[draw,circle,double,fill=green]below}
 \istb(Bad) \endist
 \istroot(1)(0-2)
 \istb(\alpha)[al]{{(1,1)}\{[red,draw=black]below}
 \istb(\beta)[ar]\{\textbf{\texttt{-1,-1}}}\{[draw,ellipse,fill=blue,yellow,inner sep=2pt]below}
 \endist
\end{istgame}
\end{verbatim}

6.3.4 Changing the input mode and text font style: \texttt{\setistmathTF(*)}

You can change the input mode for payoffs from math mode (by default) to text mode, by using \texttt{\setistmathTF010}. The last 0 means that payoffs are in text mode.

\begin{verbatim}
\% Example: \setistmathTF\begin{istgame}
 \istroot(0)
 \istb(Good)[1]{pizza 1} \istb(Bad) \endist
 \setistmathTF010 \% payoffs: in text mode
 \istroot(1)(0-2)
 \istb(\alpha)[al]{out 1} \istb(\beta)[ar]{in 1} \endist
\end{istgame}
\end{verbatim}

The starred version, for example, \texttt{\setistmathTF*010[texttt]}, with a font style specified in brackets, prints payoffs in typewriter font.

\begin{verbatim}
\% Example: \setistmathTF*
\begin{istgame}
 \istroot(0)
 \istb(Good)[1]{pizza 1} \istb(Bad) \endist
 \setistmathTF*010 \% payoffs: in texttt
 \istroot(1)(0-2)
 \istb(\alpha)[al]{out 1} \istb(\beta)[ar]{in 1} \endist
\end{istgame}
\end{verbatim}

The supplementary macro \texttt{\xtPayoff} prints, outside of a simple tree, payoffs in math mode. The starred version \texttt{\xtPayoff*} prints payoffs in the input mode as set by \texttt{\setistmathTF*}. See Section 7 on page 36.
7 Input mode and text font style changer: \texttt{\setistmathTF}(*)

The macro \texttt{\setistmathTF} enables you to change the input mode for important labels: owners, action labels, and payoff. It takes three numbers (0 or 1) as mandatory arguments. Here, 1 (true) means the input mode is in math mode and 0 (false) in text mode. The three numbers represent the input mode for owners, action labels, and payoffs, respectively. In this package, it is initially set as \texttt{\setistmathTF{0}{1}{1}}, meaning that owners are to be input in text mode, and action labels and payoffs in math mode.

% \setistmathTF
% syntax:
% \setistmathTF{<owner input mode>}{<action input mode>}{<payoff input mode>}
% initial values:
% \{0\}{1}{1}

The starred version \texttt{\setistmathTF*} accepts (in addition to three mandatory numbers) three optional arguments, each of which is effective only when the corresponding input mode is in text mode. The arguments are to be one of text font styles without a backslash such as \texttt{\textit}, \texttt{\textbf}, \texttt{\scriptsize}, \texttt{\textsf}, \texttt{\texttt}, \texttt{\textup}, and so on. Each of the three optional arguments is ignored when used with \texttt{\setistmathTF} and when the corresponding input mode is in math mode.

% \setistmathTF
% syntax:
% \setistmathTF{}{}{}<owner font>{<action label font>}{<payoff font>}
% defaults
% \{0\}{1}{1}<>{\textit}\[{}\]

The first optional argument in angle brackets is the font style for an owner, the second in curly braces for action labels, and the third in brackets for payoffs. By default action labels are printed in italics.

For example, with \texttt{\setistmathTF*000<texttt>{\textit}\[\tiny\]} deferred, an owner is printed in typewriter font, action labels in italics, and payoffs in the tiny size of normal text font (roman, upright). With \texttt{\setistmathTF000<texttt>{\textit}\[\tiny\]}, all the optional arguments are ignored and all the labels are printed in normal text font. Note also that with \texttt{\setistmathTF*001}, you can print action labels in italics (by default).

7.1 \texttt{\setistmathTF}: input mode changer

The macro \texttt{\setistmathTF} is an input mode changer, taking three numbers as mandatory arguments. The default input modes for important labels are set as \texttt{\setistmathTF011}.

% Example: \setistmathTF
% begin{istgame}
% \setistmathTF011 % (default mode)
% \xtdistance{20mm}{20mm}
% \istroot{0}{Alan 1}+20mm...40mm+
% \istb{left 1}[al]
% \istb[right 1][ar] \endist
% \setistmathTF001 % mode: text,text,math
% \istroot{1}(0-1)<180>{Bob 2}
% \istb{left 2}[al]{pie 1}
% \istb[right 2][ar]{pie 2} \endist
% \setistmathTF100 % mode: math,text,text
% \istroot{2}(0-2)<0>{Kim 3}
% \istb{left 3}[al]{pie 3}
% \istb[right 3][ar]{pie 4} \endist
% end{istgame}
7.2 \setistmathTF*: input mode and text font style changer

The starred version \setistmathTF* is a text font style changer as well as an input mode changer. It takes three numbers as mandatory arguments followed by three optional arguments in the order of \(<\{\]\. The first option \(<\) is for an owner, the second \{\} for action labels, and the third \[\] for payoffs.

Each optional argument should be one of valid font shapes and sizes, but without a textbackslash (not as a command), such as \textbf, \textsc, \textit, \texttt, \large, \tiny, and so on. Each of the options is effective only when it is used with the starred version \setistmathTF* and the corresponding input mode is in text mode.

Remark: Note that if the second optional argument is omitted when action labels are in text mode, for example, like \setistmathTF*001, action labels are printed in italics by default.

\begin{verbatim}
\setistmathTF*
\begin{istgame}
  \xtdistance{20mm}{20mm}
  \setistmathTF*011\textsc}{tiny}{textbf
  \istroot(0)\{Alan 1\}+20mm..40mm+
    \istb(left 1)[al]
    \istb(right 1)[ar]  \endist
  \setistmathTF*001\textsc}{tiny}{textbf
  \istroot(1)\{G-1\}<180\{Bob 2\}
    \istb(left 2)[al]{pie 1}
    \istb(right 2)[ar]{pie 2}  \endist
  \setistmathTF*\textbf
  \istroot(2)\{G-2\}<0\{Kim 3\}
    \istb(left 3)[al]{pie 3}
    \istb(right 3)[ar]{pie 4}  \endist
\end{istgame}
\end{verbatim}

7.3 \setistmathTF* and supplementary macros \xtFoo* printing labels

Many supplementary macros, working outside of a simple tree, optionally print important labels: owners, action labels, and payoffs. These include \xtOwner, \xtActionLabel, \xtPayoff, \xtInfosetOwner and many more. All of the macros for information sets (except \cntmAInfoset and \cntmAInfosetO) such as \xtInfoset or \xtCInfosetO also print the owners of information sets. With any supplementary macros, by default, an owner is printed in text mode and action labels and payoffs are printed in math mode.

All of these macros have their own starred (*) versions, which print the labels in the input mode as set by \setistmathTF* (but not by \setistmathTF). For example, \xtActionLabel* prints action labels in \textit\textit\textit with \setistmathTF*001, while \xtActionLabel prints action labels in \textbf\textbf\textbf mode.

\begin{verbatim}
\setistmathTF*
\begin{istgame}
  \xtdistance{20mm}{20mm}
  \setistmathTF*000\textsc}{tiny}{textbf
  \istroot(0)+20mm..40mm+ \istb \istb \endist
  \istroot(1)\{G-1\} \istb \istb \endist
  \xtOwner*(0)\{Alan 1\} \xtOwner(1)\{Bob 2\}[1]
  \xtActionLabel(0)\{G-1\}\{left 1\}[al]
  \xtActionLabel*(1)\{G-2\}\{left 2\}[al]
  \xtPayoff*(1-1){pie 1}
\end{istgame}
\end{verbatim}
You can find more examples for supplementary macros in this regard that are scattered here and there throughout the manual in appropriate places. See Section 6.1.4 Section 6.2.5 Section 6.3.4.

Here are some more examples on owners of information sets (see Section 10 for more details on information sets).

\begin{istgame}
\setistmathTF*011<textsc>
\istroot(0){Alice}+15mm..30mm+ \istb(A) \istb(B) \endist
\istroot(1)(0-1)<135>{Ben} \istb(C) \istb(D) \endist
\istroot(2)(0-2) \istb(a) \istb(b) \endist
\istroot(3)(1-2) \istb(a) \istb(b) \endist
\setistmathTF*011\textbf{t}
\xtInfosetO(0)(0)
\xtInfosetO[rectangle,rounded corners=.2em](1)(1)
\xtInfosetO*[ellipse,fill=blue!60](3)(2){Cate}[sloped,white](1.5em)
\end{istgame}

\begin{istgame}
\setistmathTF*100{texttt}
\istroot(0){\alpha}+15mm..30mm+
\istb(Left)[al] \istb(Right)[ar] \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2)
\istb \istb[Go]{omega} \endist
\xtInfosetO*(1)(2)
\xtInfosetOwner*+(1)(2){\beta}[a]
\setistmathTF*011\texttt{t}
\xtCInfosetO*(1-1)(2-1){Ben}
\xtCInfosetO*(1-2)(2-2){Cate}
\end{istgame}

\begin{istgame}
\setistmathTF*011<texttt>
\istroot(0){Alice}+15mm..30mm+
\istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2)
\istb \istb Go \omega \endist
\xtCInfosetO*(1)(0){imperfect recall}[left]
\xtCInfosetO*[dashed,blue,thick](1)(2)<.7>{\textcolor{blue}{Blue}}
\xtCInfosetO*(1-1)(2-1){Ben}
\xtCInfosetO*(1-2)(2-2){Cate}
\end{istgame}
8 Fine-tuning positions of players, action labels, and payoffs (experimental)

8.1 Fine-tuning positions: owners

If you are not satisfied the position of an owner (or a player), you can change it by using the TikZ options such as `xshift`, `yshift`, or `label distance` with the angle option of `\istroot`.

Examples are `<[xshift=10pt]above>{Child}` and `<[label distance=-5pt]45>{Parent}`, as shown in the following:

```
\begin{istgame}
\istroot(0)<[xshift=10pt]above>{Child}
\istb
\istb
\endist
\istroot(1)(0-2)<[label distance=-5pt]45>{Parent}
\istb
\istb
\endist
\end{istgame}
```

8.2 Fine-tuning positions: action labels

8.2.1 Abbreviations: `[l]`, `[r]`, `[a]`, and `[b]`

As discussed in 5.1 on page 18, the macro `\istb` deals with the action labels.

In order to determine the direction of action labels for branches to put, you can use degrees, the compass directions, or the positional words and their abbreviations as mentioned above. (Internally, the abbreviations for payoffs and those for action labels work slightly differently in terms of `xshift` and `yshift`.)

```
\begin{istgame}[scale=1.2]
\xtShowEndPoints
\xtdistance{12mm}{16mm}
\istroot(0)[initial node]
\istb<grow=0>{\fbox{$a$}}[a] \istb<grow=90>{\fbox{$1$$(a)$}}[l]
\istb<grow=180>{\fbox{$b$}}[b] \istb<grow=-90>{\fbox{$r$}}[r]
\endist
\end{istgame}
```

When you use these abbreviations you can manipulate the horizontal and/or the vertical shifts toward branches by using `\xtALPush`. (This is experimental!)

```
\begin{istgame}
\xtALPush{-3pt}{5pt}
\end{istgame}
```

For example, `\xtALPush{-3pt}{5pt}` draws the labels left and right by 3pt to the branch and push those put above and below 5pt away from the branch, as shown in the following:
8.2.2 Abbreviations: \[al\], \[ar\], \[bl\], and \[br\]

You can also use the abbreviations \[al\], \[ar\], \[bl\], and \[br\] to represent \textit{above left}, \textit{above right}, \textit{below left}, and \textit{below right}, respectively, to position action labels. Precise representation of abbreviations is as follows:

- \[al\] represents \([\text{above left}, \text{xshift}=1\text{pt}, \text{yshift}=-2\text{pt}, \text{black}]\)
- \[ar\] represents \([\text{above right}, \text{xshift}=-1\text{pt}, \text{yshift}=-2\text{pt}, \text{black}]\)
- \[bl\] represents \([\text{below left}, \text{xshift}=1\text{pt}, \text{yshift}=2\text{pt}, \text{black}]\)
- \[br\] represents \([\text{below right}, \text{xshift}=-1\text{pt}, \text{yshift}=2\text{pt}, \text{black}]\)

\begin{tcblisting}[listing above text]
\begin{istgame}[scale=1.1]
\xtShowTerminalNodes[oval node,line width=.3pt]
\def\xbox#1{\fbox{$#1$}}  \def\ybox#1{#1}
\xtdistance\{12mm\}{16mm}
\istroot(0)[initial node]
\istb\{grow=0\}{\ybox{a}}[a] \istb\{grow=90\}{\ybox{l}}[l] \istb\{grow=180\}{\ybox{b}}[b] \istb\{grow=-90\}{\ybox{r}}[r]
\endist
\begin{scope}[line width=1.2]
\xtdistance\{10mm\}{20mm}
\istroot\{90\}[N](0-2)
\istb\{red\}{\xbox{br}}[br]\{1,1\} \istb\{blue,dashed\}{\xbox{bl}}[bl]\{2,2\}
\endist
\istroot\{180\}[W](0-3)
\istb\{green\}{\xbox{ar}}[ar]\{0,3\} \istb\{red\}{\xbox{br}}[br]\{2,1\}
\endist
\istroot\{90\}[-90\{S\}](0-4)
\istb\{dotted\}{\xbox{al}}[al]\{1,-1\} \istb\{green\}{\xbox{ar}}[ar]\{-1,1\}
\endist
\istroot(0)[E](0-1)
\istb\{blue,dashed\}{\xbox{bl}}[bl]\{1,3\} \istb\{dotted\}{\xbox{al}}[al]\{2,0\}
\endist
\foreach \x in {1,...,4} {\xtNode\{0-\x\}}
\end{scope}
\end{istgame}
\end{tcblisting}

Figure 1: positioning action labels with the abbreviations
In Figure 1, \(al\)'s are put in the same position from dotted branches, and so are the other labels from their corresponding branches, like \(bl\)'s from the blue dashed branches.

You can also use \(\texttt{xtALShift}\) to put and push labels horizontally and vertically. (This is experimental!)

```
\begin{verbatim}
\% syntax:
\texttt{xtALShift\{<horizontal shift dim>\}\{<vertical shift dim>\}}
\% defaults:
\{1pt\}\{2pt\}
\end{verbatim}
```

When the dimensions get bigger than the defaults (1pt and 2pt) the labels get closer to the midpoints of the corresponding branches, and when the numbers get smaller the labels get farther from their branches.

8.3 Fine-tuning positions: payoffs

You can change the position of payoffs with \texttt{TikZ} options: \texttt{xshift} and \texttt{yshift}. For example, you can do as shown in the following:

```
\begin{verbatim}
\% Example: payoffs
\begin{istgame}
\istroot(0)\istb{Good}\{l\}\{0,2\}\istb{Bad}\endist
\istroot(1)\istb{\alpha}\{al\}\{1,1\}\{xshift=-10pt\}below\istb{\beta}\{ar\}\{-1,-1\}\{yshift=-10pt\}below\endist
\end{istgame}
\end{verbatim}
```

9 Growing direction of trees

You can draw a game tree that grows in any direction. By default, a game tree grows down and the child branches are arranged and named counterclockwise with respect to their parent node. When a tree grows down, the branches are arranged from left to right. When a tree grows to the right, the branches are arranged and named from below to above.

Sometimes you may want a tree with the branches arranged clockwise with respect to their parent node because it seems to look more natural, especially when a tree grows north or east. In \texttt{TikZ}, \texttt{grow'=<direction>} enables you to draw a tree developed clockwise.

To deal with the direction of the tree growth and the order of arranging branches, this package provides \texttt{\setistgrowdirection'} as well as \texttt{\setistgrowdirection}.  

9.1 \texttt{\setistgrowdirection{\texttt{south}}} — counterclockwise

Our first example is a tree drawn using the default values: growing \texttt{south} with branches going counterclockwise with respect to their parent nodes (from left to right).

```
% Example 1: \texttt{\setistgrowdirection{\texttt{south}}}
\begin{istgame}
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints[oval node]
\istrooto{0}{0}{+12.5mm}{3.45cm}+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istrooto{1}{0-1}{1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istrooto{2}{0-2}{2}
\istb{}{6}[center] \istb{}{7}[center] \endist
\end{istgame}
```

By default or with \texttt{\setistgrowdirection{\texttt{south}}}, the numbers written in the child nodes increase counterclockwise with respect to their parent nodes.

9.2 \texttt{\setistgrowdirection{'\texttt{south}}} — clockwise

```
% Example 2: \texttt{\setistgrowdirection{'\texttt{south}}} 
\begin{istgame}
\setistgrowdirection{'\texttt{south}}
% same codes as in Example 1
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints[oval node]
\istrooto{0}{0}{+12.5mm}{3.45cm}+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istrooto{1}{0-1}{1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istrooto{2}{0-2}{2}
\istb{}{6}[center] \istb{}{7}[center] \endist
\end{istgame}
```

With \texttt{\setistgrowdirection{'\texttt{south}}}, the numbers written in the child nodes increase \texttt{clockwise} with respect to their parent nodes, which does not look natural.
9.3 Examples of rotating trees with `\setistgrowdirection`

This macro allows you to rotate a game tree.

When you rotate a game tree to the north or to the east, it is a good idea to use the swap version `\setistgrowdirection'`.

**Tips:** Though it is not necessary, it is suggested to use the following combinations of the macros and the directions.

- `\setistgrowdirection{south}`: branches going counterclockwise (from left to right)
- `\setistgrowdirection{west}`: branches going counterclockwise (downward)
- `\setistgrowdirection'{north}`: branches going clockwise (from left to right)
- `\setistgrowdirection'{east}`: branches going clockwise (downward)

**Remark:** When you use the swap version `\setistgrowdirection'`, using either \istroot or \istroot' gives you the same result.

### 9.3.1 A tree growing east – counterclockwise

```latex
\begin{istgame}
\setistgrowdirection{east}
% same codes as in Example 1
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints[oval node]
\istroot(0){0}+(12.5mm)...(3.45cm)+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istroot(1)(0-1){1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istroot(2)(0-2){2}
\istb{}{6}[center] \istb{}{7}[center]
\endist
\end{istgame}
```

Numbers increase upward (or counterclockwise).

### 9.3.2 A tree growing east – clockwise

```latex
\begin{istgame}
\setistgrowdirection'{east}
% same codes as in Example 1
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints[oval node]
\istroot(0){0}+(12.5mm)...(3.45cm)+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istroot(1)(0-1){1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istroot(2)(0-2){2}
\istb{}{6}[center] \istb{}{7}[center]
\endist
\end{istgame}
```

Here, numbers increase downward (or clockwise). This looks more natural.
9.3.3 A tree growing north – counterclockwise

![Diagram of a tree growing counterclockwise]

Example 5:

```
\setistgrowdirection{north}
\begin{istgame}
\setistgrowdirection{north}
% same codes as in Example 1
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints{oval node}
\istrooto(0){0}+(12.5mm)..(3.45cm)+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istrooto(1){0-1}{1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istrooto(2){0-2}{2}
\istb{}{6}[center] \istb{}{7}[center]
\endist
\end{istgame}
```

Numbers increase from right to left (or counterclockwise).

9.3.4 A tree growing north – clockwise

![Diagram of a tree growing clockwise]

Example 6:

```
\setistgrowdirection'{north}
\begin{istgame}
\setistgrowdirection'{north}
\setistOvalNodeStyle{.6cm}
\xtShowEndPoints{oval node}
\xtdistance{12.5mm}{11.5mm}
\istrooto(0){0}+(12.5mm)..(3.45cm)+
\istb \istb \endist
\xtdistance{12.5mm}{11.5mm}
\istrooto(1){0-1}{1}
\istb{}{3}[center] \istb{}{4}[center]
\istb{}{5}[center] \endist
\istrooto(2){0-2}{2}
\istb{}{6}[center] \istb{}{7}[center]
\endist
\end{istgame}
```

Numbers increase from left to right (or clockwise). This looks more natural.

9.3.5 `\setxtgrowkey` for one simple tree

`\setxtgrowkey` can be used to change the key between `grow` and `grow'`, which is useful especially for one simple tree, not a whole tree.

```
\setxtgrowkey: definition
\NewDocumentCommand\setxtgrowkey{m}
{\renewcommand\xtgrow{#1}}
% #1 is either grow or grow'
```

The example below shows that the branches are arranged clockwise by `\setistgrowdirection'`. So you will need to use `\setistgrow{grow}` to locally get back to `counterclockwise`.  

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You can do the same thing by using `\setistgrowdirection` and `\istroot'`. See the following example, in which you do not need to use `\setxtgrowkey`.

10 Information sets

10.1 \xtInfoset: standard version

The macro `\xtInfoset` draws an information set, connecting two decision nodes.

The starred version `\xtInfoset*` prints the owner of an information set in input mode and text font style as set by `\setistmathTF(*)` (see page 38 for examples).

Remark: This package provides macros to draw various types of information sets. They all include an option style `[info set style]`, which is equivalent to `[semithick,densely dotted]`. You can change the style or add more options to it by using the macro `\setxtinfosetstyle`. For more details, see Section 10.2.3 on page 48.
When you specify the owner of an information set, it appears (by default) above the midpoint of the two nodes. To change the location of the information set owner, you can use the abbreviations of directional words like a, l, ar, or bl. However, when you use other options with the position you cannot use the abbreviations. If you want an owner in red on the left, you can do it like [left,red] as shown below.

\begin{verbatim}
\begin{istgame}
  \setistgrowingdirection'{east}
  \setxtinfosetstyle{dashed} \% changes line style
  \istroot(0){1}+15mm..30mm+
    \istb(a) \istb(b) \endist
  \istroot(1){0-1}
    \istb(c) \istb(d) \endist
  \istroot(2){0-2}
    \istb(c') \istb(d') \endist
  \xtInfoset(1)(2){2}[left,red]
\end{istgame}
\end{verbatim}

For a curved information set, you can do, for example, like \texttt{\xtInfoset[bend left](1)(2)}. However this depends on the direction of tree growing or swapping the arrangement of branches. So, in order to draw a curved information set, it is recommended for you to use the curved version \texttt{\xtCInfoset}, documented in Section 10.3 on page 50.

10.2 \texttt{\xtInfosetO}: oval version

10.2.1 \texttt{\xtInfosetO}: basics

The oval version \texttt{\xtInfosetO} prints a bubble type (by default, a rounded rectangle) information set connecting two nodes, on the background layer by default. However, when you specify two identical nodes, it prints a densely dotted circle (by default) at the node to express a singleton information set.

Its starred version \texttt{\xtInfosetO*} prints the owner of an information set in input mode and text font style as set by \texttt{\setistmathTF(*)} (see page 38 for examples).

\begin{verbatim}
\% \xtInfosetO (from left to right)
\% syntax:
\% \xtInfosetO(<bubble opt>)(<from>)(<to>){<owner>}[<pos>,<owner opt>](min. height)
\% defaults: connecting two nodes: \xtInfosetO(coor1)(coor2)
\% [ rectangle,rounded corners=.5*<minimum height>*<xtscale>,
\%   minimum width=\n1+<minimum height>,minimum height=1em,inner sep=0pt,
\%   infoset style ]
\% (<m>)(<m>){}[](1em)
\% option style for (all) information sets
\% infoset style={semithick,densely dotted}
\end{verbatim}

Here is an example that shows a bubble type information set as a rounded rectangle and a singleton information set as a circle.

\begin{verbatim}
\% Example: \xtInfosetO
\begin{istgame}
  \istroot(0){1}+15mm..30mm+
    \istb(a) \istb(b) \endist
  \istroot{1}{0-1}
    \istb(c) \istb(d) \endist
  \istroot{2}{0-2}
    \istb(c') \istb(d') \endist
  \xtInfosetO(0)(0)
  \xtInfosetO(1)(2){2}
\end{istgame}
\end{verbatim}
The height (or thickness) of an information set does not depend on scale, xscale, nor yscale.

Example:
```
\begin{istgame}[xscale=1.2,yscale=.7]
\istroot(0){1}+15mm..30mm+
 \istb(a) \istb(b) \endist
\istroot(1)(0-1) \istb(c) \istb(d) \endist
\istroot(2)(0-2) \istb(c') \istb(d') \endist
\xtInfosetO(0)(0)
\xtInfosetO(1)(2)(2em)
\end{istgame}
```

The size of an information set adjusts accordingly to the scale values.

Remark:
- The (minimum) height of a bubble type information set is 1em by default. This can be changed by the last optional argument of \texttt{xtInfosetO}, like \texttt{xtInfosetO(1)(2)(2em)}.
- The width of a bubble information set is \texttt{\textbackslash n1+<minimum height>} by default, where \texttt{\textbackslash n1} is the Euclidean distance (measured by Ti\TeX) between two nodes in an information set.

Example: \texttt{xtInfosetO: changing shape or color}
```
\begin{istgame}
\setistgrowdirection'{east}
\istroot(0){1}+15mm..30mm+
 \istb(a) \istb(b) \endist
\istroot(1)(0-1) \istb(c) \istb(d) \endist
\istroot(2)(0-2) \istb(c') \istb(d') \endist
\xtInfosetO[fill=blue!20,minimum width=\textbackslash n1+3em](1)(2)(2em)
\xtInfosetO(0)(0)(3em)
\end{istgame}
```

The shape of an information set does not depend on the direction of tree growing, either. You can change the shape to, for example, an ellipse by specifying it in the first bracket option list. You can also change the color of the bubble representing an information set by specifying it in the option list.

Example: south east and yscale
```
\begin{istgame}[yscale=1.5]
\setistgrowdirection'{south east}
\istroot(0) \istb \istb* \endist
\istroot(1)(0-1){2} \istb* \istb* \endist
\setxtinfosetstyle{fill=red!20,ellipse}
\xtInfosetO(0)(0-2){1}
\setxtinfosetstyle{solid,fill=blue!40,opacity=.5}
\xtInfosetO(1-1)(1-2){3}
\setxtinfosetstyle % restore defaults
\xtInfosetO(1){1}
\end{istgame}
```

Note that, in the above example, \texttt{\setxtinfosetstyle} is used to change the style of information sets. In order to restore the option value to default (i.e., \texttt{semithick,densely dotted}) just declare \texttt{\setxtinfosetstyle}. (See Section 10.2.3 on page 48.)

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## 10.2.2 Sloped information sets

With the istgame package, a sloped information set is not special. Just connect any two nodes using \xtInfoset or \xtInfosetO.

% Example: sloped infoset
\begin{istgame}
\istroot(0)\{Alice\}+15mm..30mm+ \istb(A) \istb(B) \endist
\istroot(1)(0-1)<135\{Ben\} \istb(C) \istb(D) \istroot(2)(0-2) \istb(a) \istb(b) \endist
\istroot(3)(1-2) \istb(a) \istb(b) \istroot(4)(2) \endist
\xtInfosetO(0)(0)(2em)
\xtInfosetO\[rectangle\](1)(1)
\xtInfosetO*[ellipse,fill=blue!60](3)(2){Cate} \end{istgame}

If you want to have an owner sloped too, you need the option [sloped], as shown below.

% Example: sloped infoset with sloped text
\begin{istgame}
\setistgrowdirection'\{east\}
\istroot(0)\{Alice\}+15mm..30mm+ \istb(A) \istb(B) \endist
\istroot(1)(0-1)<135\{Ben\} \istb(C) \istb(D) \istroot(2)(0-2) \istb(a) \istb(b) \endist
\istroot(3)(1-2) \istb(a) \istb(b) \setistmathTF*011<textbf>
\xtInfosetO(0)(0)
\xtInfosetO*[rectangle,rounded corners=.2em](1)(1)
\xtInfosetO*[ellipse,fill=blue!60](3)(2){Cate}[sloped,white](1.5em)
\end{istgame}

**Warning:** Issues in sloped labels in TikZ with asymmetric scales:

- The tree library in TikZ does not seem to treat sloped labels properly, when xscale or yscale is used asymmetrically.
- To cure this problem you can use \xtcureslopedlabelsNS for trees growing northwards and southwards and \xtcureslopedlabelsWS for trees growing eastwards and westwards. (See Section 6.2.3 and page 20, for more details with examples.)
- Note, however, that sloped labels for information owners printed by \xtInfosetO do not depend on scaling.

### 10.2.3 \setxtinfosetstyle

With the macro \setxtinfosetstyle you can change the style of all information sets, at once. For this end, a simple new style \texttt{infoset style} is defined as follows:

% \setxtinfosetstyle
\NewDocumentCommand \setxtinfosetstyle \{ m \}
{ \tikzset \{ \texttt{infoset style}.style = \{ \texttt{semithick}, \texttt{densely dotted}, \texttt{#1} \} \} }

You can change the line style of an information set or add more options to the option list, for example, like \texttt{\setxtinfosetstyle(thin,dashed)}, or, like \texttt{\setxtinfosetstyle(blue)}.

If you want get the option values back to the default values, then just declare \texttt{\setxtinfosetstyle}.
\begin{istgame}
\istroot(0){Alice} +15mm..30mm+
\istb \endist
\istroot(1)(0-1) \istb(1.3) \istb \endist
\istroot(2)(0-2) \istb(1.3) \istb \endist
\xtdistance{10mm}{8mm}
\istroot(3)(1-1) \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\setxtinfosetstyle{dashed,blue,thick}
\xtInfosetO(1)(2){Blue}
\xtInfosetO(1-1)(2-1)
\xtInfoset(1-2)(2-2)
\setxtinfosetstyle % restore defaults
\xtInfosetO(0)(0)
\end{istgame}

With \setxtinfosetstyle, you can also change the background color of information sets.

\begin{istgame}
\istroot(0){Alice} +15mm..30mm+
\istb \endist
\istroot(1)(0-1) \istb(1.3) \istb \endist
\istroot(2)(0-2) \istb(1.3) \istb \endist
\xtdistance{10mm}{8mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\setxtinfosetstyle{dashed,blue,thick,fill=blue!20}
\xtInfosetO(1)(2){Blue}
\xtInfosetO(1-1)(2-1)
\xtInfoset(1-2)(2-2)
\setxtinfosetstyle % restore defaults
\xtInfosetO(0)(0)
\end{istgame}

10.2.4 \setxtinfosetlayer

You can use the macro \setxtinfosetlayer to change the layer on which an information set lies from background (by default) to behind, main, above, or foreground, in that order. To go back to the default layer, just declare \setxtinfosetlayer or \setxtinfosetlayer{}.

\begin{istgame}
\setistgrowdirection '{east}
\istroot(0){}\istb(\alpha) \istb(\beta) \endist
\istroot(1)(0-1) \istb(\gamma) \istb(\delta) \endist
\istroot(2)(0-2) \istb(\epsilon) \istb(\zeta) \endist
\setxtinfosetlayer{behind}
\xtInfosetO[fill=red,ellipse,opacity=.2](0)(1)(1.5em)
\setxtinfosetlayer
\xtInfosetO[fill=blue!20](0-1)(0-2)(2em)
\end{istgame}
10.3 \texttt{\textbackslash xtCInfoset}: curved version

With the macro \texttt{\textbackslash xtCInfoset} you can draw, by default, a curved information set and even a skewed curved information set, on the background layer by default.

Its starred version \texttt{\textbackslash xtCInfoset*} prints the owner of an information set with the input mode and text font style as set by \texttt{\setistmathTF(*)} (see page 38 for examples).

### 10.3.1 Curved information sets with \texttt{\textbackslash xtCInfoset}: basics

The macro \texttt{\textbackslash xtCInfoset} connects two nodes with a curved information set like an arch that looks like a left-bent curve (by default) from start point to end point. The basic usage of \texttt{\textbackslash xtCInfoset} is the same as of \texttt{\textbackslash Infoset}.

Here is an example of drawing curved information sets.

```latex
% \texttt{\textbackslash xtCInfoset} : basics
\begin{istgame}
\istroot(0){Alice}+15mm..30mm+
\istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(0mm){10mm}
\istroot(4)(1-1) \istb \istb \endist
\istroot(5)(1-2) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\xtCInfoset(1)(0){imperfect recall}[left]
\xtCInfoset[dashed,blue,thick](1)(2){Blue}
\xtCInfoset(1-1)(2-1){Ben}
\xtCInfoset(1-2)(2-2){Cate}
\end{istgame}
```

10.3.2 Skewed \texttt{\textbackslash xtCInfoset}: full function

Besides the basic functions, \texttt{\textbackslash xtCInfoset} has two additional optional arguments to control the shape of a curved information set. With the macro \texttt{\textbackslash xtCInfoset}, you can control the shape of an information set curve by using plot factor like \texttt{<1.3>} or \texttt{<0.7>} (by default \texttt{<1.3>}) and midpoint factor like \texttt{!.4!} or \texttt{!.6!} (by default \texttt{!.5!}).

```latex
% \texttt{\textbackslash xtCInfoset} : full definition
% syntax:
\xtCInfoset[{bubble opt}]{(from)}{(to)}{\pos}{\owner opt}[\\min. height]
% defaults: connecting two nodes: \xtInfoset(coor1)(coor2)
[ rectangle,rounded corners=5*\minimum height]*\xtscale,
  minimum width=\minimum height,minimum height=1em,inner sep=0pt,
  \texttt{infoSet style} ] \% \texttt{infoSet style} = \{ \texttt{semithick, densely dotted} \}
(<m>)(<m>){}[](1em)
```

Here is another example of drawing curved information sets.

```latex
% Example: \texttt{\textbackslash xtCInfoset}
\begin{istgame}
\istroot(0){Alice}+15mm..30mm+
\istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(0mm){10mm}
\istroot(4)(1-1) \istb \istb \endist
\istroot(5)(1-2) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\xtCInfoset(1)(0){imperfect recall}[left]
\xtCInfoset[dashed,blue,thick](1)(2){Blue}
\xtCInfoset(1-1)(2-1){Ben}
\xtCInfoset(1-2)(2-2){Cate}
\end{istgame}
```
By plot factor, we mean that it determines the maximum or minimum value of a curve. If the plot factor is greater than 1 it prints a concave curve, equal to 1 a straight line, and less than 1 a convex curve, connecting form left to right. For example, \texttt{\textbackslash xtCInfoset}(1)(2)<.7> (left to right) and \texttt{\textbackslash xtCInfoset}(2)(1)<1.3> (right to left) will give the same result.

A curved information set drawn by \texttt{\textbackslash xtCInfoset} does not depend on the tree growing direction. It does not depend on scaling nor swapping branches, either.

By midpoint factor, we mean that, roughly speaking, it determines the maximum or minimum point of a curve. If the midpoint factor is less than .5 the curve is positively skewed, and greater than .5 negatively skewed.

A curved information set drawn by \texttt{\textbackslash xtCInfoset} does not depend on the tree growing direction. It does not depend on scaling nor swapping branches, either.
10.4 \texttt{xtCInfosetO}: curved oval version

The macro \texttt{xtCInfosetO} enables you to draw a \textit{curved bubble type} information set and even a \textit{skewed curved bubble type} information set on the background layer by default.

Its starred version \texttt{xtCInfosetO*} prints the owner of an information set in input mode and text font style in accordance with \texttt{\setistmathTF(*)} (see page 38 for examples).

10.4.1 Curved bubble type information sets with \texttt{xtCInfosetO}: basics

The basic usage of \texttt{xtCInfosetO} is the same as of \texttt{xtInfosetO}. If the two mandatory coordinates are identical, a \textit{circle} is drawn to represent a \textit{singleton information set}, like the case of \texttt{xtInfosetO}.

\begin{verbatim}
\% \texttt{xtCInfosetO} : basics
\% syntax:
\texttt{\texttt{xtCInfosetO}[<bubble opt>](<from>)(<to>){<owner>}[<pos>,<owner opt>](min. height)}
\% defaults: connecting two nodes: \texttt{\texttt{xtInfoset}(coor1)(coor2)}
\% [ rectangle,rounded corners=.5*<minimum height>*<xtscale>,
\% minimum width=\texttt{\texttt{n1}+<minimum height>*<xtscale>},
\% minimum height=\texttt{1em},inner sep=Opt,
\% infoest style = \{ semithick, densely dotted \}
\% (<m>)(<n>){}[]()1em
\begin{istgame}
\setistmathTF*011<texttt>
\istroot(0){Alice}+15mm..30mm+
\istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\texttt{xtCInfosetO*(1)(0){imperfect recall}[left]}
\texttt{xtCInfosetO(1-1)(2-1){Ben}}
\texttt{xtCInfosetO(1-2)(2-2){Cate}}
\end{istgame}
\end{verbatim}

The shape of information sets does not depend on the direction of tree growing. You also can change the background color and the height, like \texttt{(1.5em)} as the last option.

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\setistgrowdirection’{east}
\istroot(0){Alice}+15mm..30mm+
\istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\texttt{xtCInfosetO*[fill=blue!20](1)(0){imperfect recall}[left](.7em)}
\texttt{xtCInfosetO[fill=blue!20](1-1)(2-1){Ben}}
\texttt{xtCInfosetO*[fill=red!40,opacity=.5](1-2)(2-2)<1.3>{Cate}(1.5em)}
\end{istgame}
\end{verbatim}
10.4.2 Skewed \texttt{xtCInfosetO}: full function

Besides the basic functions, the macro \texttt{xtCInfosetO} has two additional optional arguments to control the shape of a bubble representing a curved information set. The two optional arguments are plot factor and midpoint factor. (The meanings are documented on page 51.)

The plot factor makes a curved information set higher or lower and is used in angle brackets, like \(<1.5>\) or \(<.7>\) (by default \(<1.3>\)), right after the two mandatory coordinates. The midpoint factor controls skewness of a curved information set and is used in between the two mandatory arguments, like \(!.35!\) (by default \(!.5!\)).

\begin{verbatim}
% \texttt{xtCInfosetO}: full definition
% syntax: \texttt{xtCInfosetO}(bubble opt>)(from)(midpoint factor)(to)
% defaults: connecting two nodes: \texttt{xtInfoset(coor1)(coor2)}
% [ rectangle,rounded corners=5*(minimum height)*\texttt{xscale},
% minimum width=\texttt{n1}+minimum height,minimum height=1em,
% semithick,densely dotted,inner sep=0pt ]
% (\texttt{<m>})(\texttt{<m>}){[}()]{1em}
\end{verbatim}

\begin{verbatim}
\% Example: \texttt{xtCInfosetO}: skewed
\begin{istgame}[font=\scriptsize]
\istroot(0){Alice}+15mm..30mm+
  \istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(3)(1-1) \istb \istb \endist
\istroot(4)(1-2) \istb \istb \endist
\istroot(5)(2-1) \istb \istb \endist
\istroot(6)(2-2) \istb \istb \endist
\xtCInfosetO[fill=blue!20]
  (1)(0){imperfect recall}[left]
\xtCInfosetO[dashed,blue](1)(2)<.7>{Blue}
\xtCInfosetO[1-1]!1.35!(2-1){Ben}
\xtCInfosetO[fill=red!40,opacity=.5]
  (1)(2)!1.65!(2-2)<1.5>{Cate}
\end{istgame}
\end{verbatim}

Remark:
\begin{itemize}
  \item When using \texttt{xtCInfosetO}, the recommended range of the midpoint factor is between \(.4\) and \(.6\), at most between \(.35\) and \(.65\), otherwise you might get a result with which you are not satisfied. (You can see below Section 10.5.1 on this issue, only when you are interested in.)
  \item You do not need to bother if the tree is swapped, because the package internally takes care of that instead.
  \item An information set drawn by \texttt{xtCInfosetO} is appropriately adjusted with \texttt{scale}, \texttt{xscale}, or \texttt{yscale}, but the height (or thickness) is independent of the scale values. (You can see below Section 10.5.2 on the issue of scaling, only when you are interested in.)
\end{itemize}

10.5 Fine-tuning \texttt{xtCInfosetO}: Not for most users

10.5.1 \texttt{xtCInfosetO}TurnX: too high or too low midpoint factor

What if you really want to use the midpoint factor close to 0 or 1? In this case, you will possibly get some unsatisfactory result as shown in the example below. (Note that this being unsatisfied might not happen if you use the midpoint factor within the recommended range.)
The package provides the macro \texttt{\xtCInfosetOTurnX} to make it straight.

First, find the blue circle and the red circle in the above example. Let us call by $X$ the (blue) circle at the beginning of an information set and by $Y$ at the end. With \texttt{\xtCInfosetOTurnX} you can turn these circles to get a better result.

In the following example, \texttt{\xtCInfosetOTurnX{45}{0}} and \texttt{\xtCInfosetOTurnX{0}{-45}} are used to correct the result. If you omit the second angle like, for example, \texttt{\xtCInfosetOTurnX{45}}, it is equivalent to \texttt{\xtCInfosetOTurnX{45}{-45}}, meaning that it turns the both circles symmetrically.

\begin{verbatim}
\begin{istgame}[yscale=1.5,font=\scriptsize]
\xtdistance{10mm}{10mm}
\istroot(0){Alice}+15mm..15mm+
\istb \istb \istb \istb \endist
\istroot(1){(0-1)} \istb \istb \endist
\istroot(2){(0-2)} \istb \istb \endist
\istroot(3){(0-3)} \istb \istb \endist
\istroot(4){(0-4)} \istb \istb \endist
\xtCInfosetO\texttt{\fill=blue!20}(1)!.2!(3)<1.4>{Ben}
\xtCInfosetO\texttt{\fill=red!40,opacity=.5}(2)!.8!(4)<1.5>{Cate}
\end{istgame}
\setxtinfosetlayer{behind}
\xtCInfosetOTurnX{40}{0}
\xtCInfosetO\texttt{\fill=blue!20}(1)!.3!(3)<1.4>{Ben}\texttt{[left]}
\setxtinfosetlayer{background}
\xtCInfosetOTurnX{0}{-45}
\xtCInfosetO\texttt{\fill=red!40}(2)!.7!(4)<1.5>{Cate}
\end{istgame}
\end{verbatim}

Remark:

- \texttt{\xtCInfosetOTurnX} works just once only for the following \texttt{\xtCInfosetO}, without affecting any other.
- You can also change the layer of an information set, as shown in the previous example, by using \texttt{\setxtinfosetlayer} (see Section 10.2.4).
10.5.2 Scaling information sets according to the value of Ti\kZ scale

The height (or thickness) of bubble type information sets drawn by $\texttt{xtInfosetO}$ and $\texttt{xtCInfosetO}$, does not depend on the values of Ti\kZ scales. What if you want to make them scaled according the value of Ti\kZ symmetric scale, for example, $\texttt{[scale=.5]}$? Then use, instead, $\texttt{[scale=.5,xscale=1]}$ or equivalently $\texttt{[yscale=1,scale=.5]}$ in any order of the options.

Here is an ordinary example of using $\texttt{[scale=.5]}$.

\begin{istgame}[scale=.5]
\xtdistance{40mm}{30mm}
\istroot(0)+40mm..40mm+
\istb \istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(0-3) \istb \istb \endist
\xtInfosetO[fill=green](1)(2)[green]
\xtCInfosetO(1)(3){player}(1.5em)
\end{istgame}

Here is an example to use $\texttt{[scale=.5,xscale=1]}$, where the height (or thickness) of information sets is scaled according to the value of Ti\kZ scale.

\begin{istgame}[scale=.5,xscale=1]
\xtdistance{40mm}{30mm}
\istroot(0)+40mm..40mm+
\istb \istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(0-3) \istb \istb \endist
\xtInfosetO[fill=green](1)(2)
\xtCInfosetO(1)(3){player}(1.5em)
\end{istgame}

Remark: (Not for most users) How the \texttt{istgame} environment works with the Ti\kZ scales, regarding oval type information sets.

- In the \texttt{istgame} package, it is intended that the height (or thickness) of any bubble type information set is not affected by the values of Ti\kZ scale, unless users change it. (This is a desirable feature.)
- The shapes of bubble type information sets work perfectly fine, as intended, when:
  - $\texttt{scale}$ only (not with $\texttt{xscale}$ nor $\texttt{yscale}$) is used in the environment option list
  - and either $\texttt{xscale}$ or $\texttt{yscale}$ or both (not with $\texttt{scale}$) are used in the option list.
- Now, this is how the \texttt{istgame} environment works when $\texttt{scale}$ is used with $\texttt{xscale}$ or $\texttt{yscale}$.
  - When this is the case, the value of $\texttt{scale}$ is not taken care of by the package. Only the values of $\texttt{xscale}$ and $\texttt{yscale}$ are internally extracted and used to compensate the distortion of the shapes of information sets caused by the asymmetric scaling.
  - For example, $\texttt{[scale=.5]}$ and $\texttt{[scale=.5,xscale=1]}$ are treated as different (with respect to bubble type information sets) by the \texttt{istgame} environment, while the \texttt{tikzpicture} environment treats them as equal. With the latter, the \texttt{istgame} environment does not extract the value of $\texttt{scale}$ to use it internally, but does only the value of $\texttt{xscale}$. So $\texttt{scale}$ can affect the sizes of bubble type information sets.
  - Still, the shapes of bubble type information sets drawn by this package are not distorted by the mixed (even asymmetrical) use of Ti\kZ scales. (In the case of asymmetric scaling, there is one exception for $\texttt{cntmAInfosetO}$, which is equipped with an option to cure the distortion. See Section 11.5.3 on page 69 for more details.)
11 Continuum of branches

The package istgame provides the macro `\istrootcntm` and its several variants (all prefixed by `\istroot` or `\istoott`) to express a continuum of branches and an action taken. As you will see, all the supplemental macros to a continuum of branches are prefixed by `\cntm`.

Two types of graphic objects, a triangle type and an arc type, are provided in the package to represent a continuum of branches. So you can start by choosing one type of a continuum of branches.

11.1 `\istrootcntm`: standard continuum version

The standard version `\istrootcntm` prints a background triangle, in black!25 by default, representing a continuum of branches, on the background layer by default. It works just like `\istroot`, for one exception: it controls, by the last two options `+<\cntmlevdist>..<\cntmsibdist>`+, the distances for only the background triangle, but not the `\istb`'s following it. You can regard `\istrootcntm` as the sum `\istroot + cntm`.

```
\begin{istgame}[scale=1.2]
\cntmlevdist{10mm}
\istrootcntm{}{I}+10mm..20mm+
\istb{x}[r]
\istb{y}[al]{x,1-x} \istb{n}[ar]{0,0} \endist
\end{istgame}
```

The background is an isosceles triangle, with the height of `\cntmlevdist` (8mm by default) and the base length of `\cntmsibdist` (24mm by default).

The action taken by the owner of the root has the sibling distance (to a missing branch represented by `\istbm`, if exists) of one third (by default) of the base length of the continuum triangle.

```
\begin{istgame}[scale=1.2]
\xtdistance{10mm}{20mm}
\istrootcntm{}{I}+10mm..20mm+
\istb{x}[r] \istb{y}[dashed,white] \endist
\istroot{}{I}+0mm..20mm+
\istb{y}[al]{x,1-x} \istb{n}[ar]{0,0} \endist
\end{istgame}
```
You can change the level and sibling distances of an individual continuum triangle by specifying the last two options of the macro \istrootcntm like, for example, +10mm..15mm+. Note that these options do not affect the action sibling distance.

**Remark:** Below we will see the convenient distance changers \cntmdistance and \cntmdistance* to change the distances for all types of continua. These macros also have a control on the action sibling distance.

\begin{istgame}[font=\scriptsize]
\xtdistance{10mm}{20mm}
\istrootcntm(1){1} \hspace{1cm} \% period 1
\istb{x}[r] \istbm \endist
\istroot(A1)(1-1)<[label distance=-3pt]15S>{2}
\istb{A}[al]{x,1-x} \istb{R}[ar] \endist
\istrootcntm(2)(A1-2){2}+10mm..15mm+ \% period 2
\istb{y}[r] \istbm \endist
\istroot(A2)(2-1)<[label distance=-3pt]120>{1}
\istb{A}[al]{1-y,y} \istb{R}[ar]{0,0} \endist
\istrootcntm(3)(A2-2){1} \hspace{1cm} \% period 3
\istb{x}[r] \istbm \endist
\istroot(A1)(3-1)<[label distance=-3pt]120>{2}
\istb{A}[al]{x,1-x} \istb{R}[ar]{0,0} \endist
\end{istgame}

**Remark:**
- Once the work of \istrootcntm is completed by \endist, \istrootcntm internally produces three node coordinates: \text{(cntm)}, \text{(cntm-1)}, and \text{(cntm-2)}.
- You can use these coordinates after \istrootcntm and before another \istrootcntm or one of its variant, like \istrootcntmA, is used.

\begin{istgame}[scale=1.2]
\xtdistance{10mm}{20mm}
\istrootcntm(0){I}
\istb{x}[r] \istbm \endist
\istroot(1)(0-1)<[label distance=-3pt]120>{II}
\istb{Y}[al]{x,1-x} \istb{N}[bl]{0,0} \endist
\xtInfosetO\text{(cntm)}\text{(cntm)}
\xtInfosetO\text{[draw=none,fill=red,opacity=.3]}\text{(cntm-1)}\text{(cntm-2)}
\end{istgame}

\istrootcntm’: swap version
The swap version \istrootcntm’ arranges branches clockwise just like \istroot does. With \setistgrowdirection’, both \istrootcntm and its swap version \istrootcntm’ end up with the same result.

\begin{istgame}[scale=1.2]
\setistgrowdirection’{east}
\istrootcntm'(0){I}
\istb{x}[b] \istbm \endist
\istroot(1)(0-1)<[label distance=-3pt]120>{II}
\istb{Y}[al]{x,1-x} \istb{N}[bl]{0,0} \endist
\end{istgame}
11.1.2 \cntmdistance

The macro \cntmdistance working for \istrootcntmA (and \istrootcntmA) is analogous to \xtdistance working for \istroot. As \xtdistance controls the height and width of a simple tree, \cntmdistance controls the height and width of a background triangle representing a continuum, but it has one more function. With \cntmdistance you can also control the sibling distance of action branches \((\text{action sibling distance})\) that are taken by the owner of the root.

% \cntmdistance
% syntax:
\cntmdistance{<cntm lev dist>}{<cntm sib dist>}{<action sib dist>}
% defaults: <cntm lev dist> is mandatory, and all others are optional
\{8mm\}{3\times<cntm lev dist>}{(1/3)\times<cntm sib dist>}

Note that the first argument of \cntmdistance is mandatory, and all the others are optional. For example, \cntmdistance{10mm}{20mm} means the followings:

\cntmlevdist = 10mm, \cntmsibdist = 20mm, and
\cntmactsibdist = (1/3)\times\cntmsibdist, from now on.

And \cntmdistance{10mm}{20mm}{3mm} means now \cntmactsibdist = 3mm.

\begin{verbatim}
\% Example: \cntmdistance
\begin{istgame}[font=\scriptsize]
\xtdistance{10mm}{20mm}
\cntmdistance{10mm}{20mm}{3mm}
\istrootcntm(1){1} \% period 1
\istb{x}{x} \istbm \endist
\istroot(A1){1-1}{[label distance=-3pt]135}{2}
\istb{A}{al}{x,1-x} \istb(R){ar} \endist
\istrootcntm(2){A1-2}{2} \% period 2
\istb{y}{y} \istbm \endist
\istroot(A2){2-1}{[label distance=-3pt]135}{1}
\istb{A}{al}{1-y,y} \istb(R){ar} \endist
\istrootcntm(3){A2-2}{1} \% period 3
\istb{x}{x} \istbm \endist
\istroot(A1){3-1}{[label distance=-3pt]135}{2}
\istb{A}{al}{x,1-x} \istb(R){ar}{0,0} \endist
\end{istgame}
\end{verbatim}

11.1.3 \cntmdistance*: combined with \xtdistance

The macro \cntmdistance* incorporates \cntmdistance with \xtdistance.

% \cntmdistance*
% syntax:
\cntmdistance*{<lev dist>}{<sib dist>}{<action sib dist>}
% defaults: \{15mm\}{15mm}{(1/3)\times<cntm sib dist>}

The macro \cntmdistance does not have anything to do with \xtdistance, but the starred version \cntmdistance* does. For example, \cntmdistance*{10mm}{20mm} means the followings:

\cntmlevdist = \xtlevdist = 10mm, \cntmsibdist = \xtsibdist = 20mm, and
\cntmdistance = (1/3)\times\cntmdisdist, from now on.

And \cntmdistance*{10mm}{20mm}{3mm} means now \cntmactsibdist = 3mm.
11.1.4 \cntmpreset: controlling continuum triangles

The macro \cntmpreset controls the line style and color, size (via the shrink factor with 1 as default), and fill color of a continuum triangle drawn by \istrootcntm.

\begin{verbatim}
\cntmpreset
% syntax: \cntmpreset[<line style>,<opts>]{{<shrink factor>}}{<fill color>}
% defaults [-,solid,draw=black!25,fill=<draw color>]{{1}}{}
\end{verbatim}

To change the background color you can do like, for example, either \cntmpreset[blue!20] or \cntmpreset[]{}[blue!20]. However, like \cntmpreset[blue!20][red!20], if you specify both of the bracket optional arguments, then the first one wins. The second bracket option is just for your convenience to put fill color easily.

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}{3mm}
\istrootcntm(1)
 \istb \istbm \endist
\istroot(A1)(1-1)
 \istb \istb \endist
\cntmpreset{draw=blue,dashed}[red!20]
\istrootcntm(2)(A1-2)
 \istb \istbm \endist
\istroot(A2)(2-1)
 \istb \istb \endist
\cntmpreset[blue!20][red!20]
\istrootcntm(3)(A2-2)
 \istb \istbm \endist
\istroot(A1)(3-1)
 \istb \istb \endist
\end{istgame}
\end{verbatim}

You can also draw a smaller triangle, by specifying shrink factor as a decimal number in the curly braces.

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}
\cntmpreset{.7}
\istrootcntm(1) \istb \endist
\istroot(A1)(1-1) \istb \istb \endist
\cntmpreset[draw=blue,dashed]{.8}[red!20]
\istrootcntm(2)(A1-2) \istb \istbm \endist
\istroot(A2)(2-1) \istb \istb \endist
\end{istgame}
\end{verbatim}
11.1.5 \cntmpreset*: simple triangles with no background color

The macro \cntmpreset* works like \cntmpreset, for one exception: it prints, by default, a simple triangle with sides drawn, but with no background color.

\begin{verbatim}
\%
\cntmpreset
\%
syntax:
\cntmpreset*[<line style>,<opts>]{<shrink factor>}[<fill color>]
\%
defaults
\[-,solid,draw=black,fill=none]\{1\}[]
\%
\end{verbatim}

Remark: In order to restore the standard triangle options (i.e., \[-,draw=none,black!25\]), you can just declare \cntmpreset followed by nothing. More precisely, if you use \cntmpreset without specifying the first bracket option, like \cntmpreset{.7}, the default options are restored.

You can also draw a smaller triangle, by specifying shrink factor as a decimal number in the curly braces.

\begin{verbatim}
\%
\cntmpreset{(*)}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}
\cntmpreset*
\istrootcntm(1)
 \istb \endist
 \istroot(A1)(1-1)
 \istb \istb \endist
 \cntmpreset*[fill=blue!20]
 \istrootcntm(2)(A1-2)
 \istb \endist
 \istroot(A2)(2-1)
 \istb \istb \endist
 \cntmpreset % restore default triangle options
 \istrootcntm(3)(A2-2)
 \istb \istbm \endist
 \istroot(A1)(3-1)
 \istb \istb \endist
\end{istgame}
\end{verbatim}

\begin{verbatim}
\%
\cntmpreset{(*)}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}
\cntmpreset{.5}
\istrootcntm(1)
 \istb \endist
 \istroot(A1)(1-1)
 \istb \istb \endist
 \istrootcntm(2)(A1-2)
 \istb \endist
 \istroot(A2)(2-1)
 \istb \istb \endist
 \cntmpreset{.7} % restore default triangle options
 \istrootcntm(3)(A2-2)
 \istb \istbm \endist
 \istroot(A1)(3-1)
 \istb \istb \endist
\end{istgame}
\end{verbatim}
11.2 \istrootcntmA: continuum arc version

11.2.1 \istrootcntmA: basics

The macro \istrootcntmA works just like \istroot, but it draws an arc to express a continuum of branches. Here cntmA is an abbreviation of cntmarc. You can regard \istrootcntmA as the sum \istroot + cntmA.

Remark:

- There is one important difference between \istroot and \istrootcntmA. By the last two options (for example, +10mm..20mm+), the \istrootcntmA controls the level and sibling distances of a continuum arc, while \istroot controls the level and sibling distances of action branches (represented by the \istb) following it.
- Note that the distance changers \cntmdistance and \cntmdistance* work the same for \istrootcntmA as well as \istrootcntm. (There is no such thing as \cntmAdistance.)

\begin{verbatim}
\[\text{\istrootcntmA syntax:}\]
\istrootcntmA[<grow keyval>,<opt>][<coor1>][<coor2>][<node style>,<opt>][<arc pos>{<owner}>]+<cntm levdist>..<cntm sibdist>+
\end{verbatim}

The default level and sibling distance of a continuum of branches are 8mm and 3*8mm. With the default distances, the distance between the root and the lowest point of the arc is one third longer (with all default values) than the continuum level distance.

With the macro \istbA you can draw a single branch ending up with an endpoint on the continuum arc. Just remember \istb always reaches the red dashed line and \istbA the blue dashed line. For more details, see below Section 11.2.2 (though it is not for first readers).
The swap version \texttt{\textbackslash istrootcntmA}' arranges branches clockwise, like \texttt{\textbackslash istroot}' does. Note also that if you use \texttt{\textbackslash setistgrowdirection}', then using the swap version makes no difference in results.

\begin{verbatim}
\% Example: \texttt{\textbackslash istrootcntmA}' (growing east)
\begin{istgame}[scale=1.2]
\setistgrowdirection'{east}
\istrootcntmA'(0){I}
\istb<llevel distance=1.3*\cntmlevdist>{x}{b} \istbm
\endist
\xtdistance{10mm}{20mm}
\istroot{(1)}{0<120}{II}
\istb{Y}[al]{x,1-x} \istb{N}[bl]{0,0} \endist
\end{istgame}
\end{verbatim}

11.2.2 \texttt{\textbackslash istrootcntmA} and \texttt{\textbackslash istbA}

As discussed in Section 5.5 on page 26 \texttt{\textbackslash istb} and \texttt{\textbackslash istbA} can be used interchangeably (but with one exception). However, when it comes to \texttt{\textbackslash istrootcntmA}, \texttt{\textbackslash istbA} has a unique function: it reaches a continuum arc.

To be precise, \texttt{\textbackslash istbA} reaches the blue dashed line, as shown in the above picture, while \texttt{\textbackslash istb} reaches the red dashed line. So when \texttt{\textbackslash istbA} is the only child of the root, it arrives exactly at the continuum arc.

\begin{verbatim}
\% Example: \texttt{\textbackslash istrootcntmA} and \texttt{\textbackslash istbA}
\begin{istgame}[scale=1.2]
\istrootcntmA(0)
\istbA*
\istbA*
\istbA*
\endist
\xtTimeLineH[dashed,blue](0-2){-1.5}{1.5}
\end{istgame}
\end{verbatim}

Moreover, as also discussed in Section 5.5 on page 26, \texttt{\textbackslash istbA} has one more function than \texttt{\textbackslash istb}: it can easily change its level distance by using the first parenthesis option. This allows you to make any \texttt{\textbackslash istbA} reach the continuum arc, but after some trial and errors.

\begin{verbatim}
\% Example: \texttt{\textbackslash istrootcntmA} and \texttt{\textbackslash istbA}
\begin{istgame}[scale=1.2]
\istrootcntmA(0)
\istbA*(.89) \istbA* \istbA*(.89)
\endist
\istrootcntmA(1)(0-1)
\istbA*(.97) \istbA*(.97) \endist
\end{istgame}
\end{verbatim}
11.2.3 \cntmAset: controlling continuum arcs and wedges

You can control the line style, position (via arc position factor), and curvature (via arc plot factor) of a continuum arc with \cntmAset. You can also change the background color (by default transparent) of the wedge formed by a continuum arc.

You can change the line style or the color of a continuum arc, in the usual TikZ way, like [dashed, thick, blue]. If you do not specify any optional argument, the corresponding argument will have the default values. So, by declaring \cntmAset followed by nothing, you can restore all the default values.

A continuum arc connects the two endpoints, by default, of the two outermost branches. If the arc position factor (between zero and one) is less than \{.5\} the arc gets closer to the root, and if greater then it gets closer to the endpoints. (What if the factor is greater than 1? You try!)

\begin{istgame}
\cntmAdistance*{10mm}{20mm}
\cntmAset[dashed, blue, thick]
\istroot\cntmA(1)
\istbA \endist
\istroot(A1)(1-1)
\istbA \istbA \endist
\cntmAset[dashed]{.6}
\istroot\cntmA(2)(A1-2)
\istbA \endist
\istroot(A2)(2-1)
\istbA \istbA \endist
\cntmAset % restore defaults
\istroot\cntmA(3)(A2-2)
\istbA \endist
\istroot(A1)(3-1)
\istbA \istbA \endist
\end{istgame}

Note that \istbA (if it is the only child) always prints a branch with its endpoint on an arc. Note also that the effect of \cntmAset goes on until another \cntmAset, which restores the values to defaults, is used.

As for the curvature, if the factor (usually, greater than 1) typed in angle brackets is smaller than the default value <1.333> the arc gets flatter, and if larger it gets sharper. (If the factor is 1, it becomes a straight line. What if the factor is less than 1? You guess!)

\begin{istgame}
\cntmAdistance*{10mm}{20mm}
\cntmAset<1.2>
\istroot\cntmA(1)
\istbA \endist
\cntmAset[tension=1.12]<1.508>
\istroot\cntmA(2)(1-1)
\istbA \endist
\cntmAset<1.7>[green]
\istroot\cntmA(3)(2-1)
\istbA* \endist
\end{istgame}
In order to change the background color of the wedge formed by an arc, you should use the
second bracket option. The first one is for a continuum arc line. The color filled wedge lies on the
behind layer, by default. You can change the layer by using \cntmAlayerpreset. Available layers
are: background, behind, main, above, and foreground, in that order. To restore the default
layer (i.e., behind), just declare \cntmAlayerpreset.

11.3 \istrootocntm and \istrootocntmA: oval continuum versions

In some cases, you may want to use \istrootocntmA, the oval version of \istrootcntmA. It can
be regarded as the sum \istrooto + cntmA. The swap version \istrootocntmA' is also provided.

It is anyway possible to use \istrootocntm, which is the oval version of \istrootcntm. It can
be regarded as the sum \istrooto + cntm. You can also use its swap version \istrootocntm'.
11.4 Doing some chores: not for most users

11.4.1 \cntmistb: controlling outermost branches

The macro \cntmistb controls the outermost branches of a continuum triangle. This works similar to \istb, but you need to use this macro right before the \istrootcntm. And it works just once only for the immediately following \istrootcntm and its close variants, but not for the continuum arc versions.

Remark: The macro \cntmistb prints solid nodes at the endpoints of the outermost branches.

- The effect of printing solid nodes affects all the following continua. It can be turned off by the starred version \xtHideEndPoints* (see Section 11.4.3, for more details).

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntdistance*[10mm](20mm)(3mm)
\cntmistb[draw=blue,dashed]{x=0}[l]{x=1}[above,sloped]
\istrootcntm(1)
\istb \istbm \endist
\istroot(A1)(1-1)
\istb \istb \endist
\cntmistb*[blue]{x=0}[l]{x=1}[above,sloped]
\istrootcntm(2)(A1-2)
\istb \istbm \endist
\istroot(A2)(2-1)
\istb \istb \endist
\setistmathTF*000{\texttt}
\cntmistb*[red,draw=blue,thick]{x=0}[l]{x=1}[above,sloped]
\istrootcntm(3)(A2-2)
\istb \istbm \endist
\istroot(A1)(3-1)
\istb \istb \endist
\end{istgame}
\end{verbatim}

\cntmistb(*) prints action labels in math mode by default, and the input mode can be changed by \setistmathTF(*).

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntpreset*[dashed].7
\cntdistance*[10mm](20mm)(3mm)
\cntmistb{x=0}[l]{x=1}[above,sloped]
\istrootcntm(1) \istb \endist
\istroot(A1)(1-1) \istb \istb \endist
\cntmistb*[blue]{x=0}[l]{x=1}[above,sloped]
\istrootcntm(2)(A1-2) \istb \endist
\istroot(A2)(2-1) \istb \istb \endist
\setistmathTF*000{\texttt}
\cntpreset*.9[blue!20]
\cntmistb{x=0}[l]{x=1}[above,sloped]
\istrootcntm(3)(A2-2) \istb \istb \endist
\istroot(A1)(3-1) \istb \istb \endist
\end{istgame}
\end{verbatim}
11.4.2 \cntmAistb: controlling outermost branches

The macro \cntmAistb controls the outermost branches of a continuum arc. This works similar to \istb, but you need to use this macro right before the \istrootcntmA. And it works just once only for the immediately following \istrootcntmA and its close variants, but not for the continuum triangle versions.

The macro \cntmAistb* prints solid nodes at the endpoints of the outermost branches. The effect of printing solid nodes affects all the following continua. It can be turned off by the starred version \xtHideEndPoints* (see Section 11.4.3, for more details).

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}
\cntmAistb[dotted]{x=0}[above,sloped]{x=1}
\istrootcntmA(1) \istbA \endist
\istroot(A1)(1-1) \istbA \istbA \endist
\end{istgame}
\end{verbatim}

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmdistance*{10mm}{20mm}
\cntmAistb[dashed]{x=0}[l]{x=1}
\istrootcntmA(2)(A1-2) \istb \endist
\istroot(A2)(2-1) \istbA \istbA \endist
\setistmathTF*000{texttt}
\cntmAistb{red,draw=black}[x=0][1]{x=1}[above,sloped]
\istrootcntmA(3)(A2-2) \istbA \istbA \endist
\istroot(A1)(3-1) \istbA \istbA \endist
\end{istgame}
\end{verbatim}

Note that \cntmAistb controls outermost branches of a continuum, while \cntmApreset controls the arc line.

It is not impossible to print two endpoints of a continuum arc, even thought it does not make any game theoretical sense. You can easily do that by using \cntmAexpostShowEndPoints right after \istrootcntmA.

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmAistb*
\cntmApreset{.7}
\istrootcntmA(1) \istbA \endist
\istrootcntmA(A1)(1-1) \istbA* \endist
\end{istgame}
\end{verbatim}

\begin{verbatim}
\begin{istgame}[font=\scriptsize]
\cntmAistb*
\cntmApreset{.7}
\istrootcntmA(1) \istbA \endist
\istrootcntmA(A1)(1-1) \istbA* \endist
\cntmAexpostShowEndPoints
\istrootcntmA(A1)(1-1) \istbA* \endist
\cntmAexpostShowEndPoints[oval node][box node]
\end{istgame}
\end{verbatim}
11.4.3 \texttt{xtShowEndPoints*}

The starred version \texttt{xtShowEndPoints*} has additional control over the endpoints of outermost branches of a continuum, when it is used with \texttt{cntmistb} or \texttt{cntmAistb}. However, the starred versions \texttt{cntmistb*} and \texttt{cntmAistb*} do not obey \texttt{xtShowEndPoints*}. They anyway print solid nodes at the endpoints of outermost branches and the effect goes on until it is blocked by \texttt{xtShowEndPoints*} or \texttt{xtHidePoints*}.

\texttt{xtShowEndPoints*} competes with each of the starred versions \texttt{cntmistb*} and \texttt{cntmAistb*} for the control over \texttt{cntmistb} and \texttt{cntmAistb} with respect to the endpoints of outermost branches. Whichever comes later wins.

The starred version \texttt{xtHideEndPoints*} works only for the endpoints of the outermost branches to turn off the effects of \texttt{xtShowEndPoints*}, \texttt{cntmistb*}, and \texttt{cntmAistb*}. But whichever comes later wins.

Note that the non-starred versions \texttt{xtShowEndPoints} and \texttt{xtHideEndPoints} have nothing to do with the outermost endpoints of a continuum.

In the example below, \texttt{cntmistb*} overrides the effect of \texttt{xtShowPoint*}[oval node], with respect to the outermost endpoints of continua.

\begin{verbatim}
\begin{istgame}
\cntdistance*{8mm}{16mm}
\cntpreset*
\xtShowEndPoints*[oval node]
\cntmistb
\istrootcntm(1) \istb \endist
\istroot(A1)(1-1) \istb \istb \istb \endist
\cntmistb
\istrootcntm(2)(A1-2) \istb \endist
\istroot(A2)(2-1) \istb \istb \endist
\cntmAistb*
\istrootcntm(3)(A2-2) \istb \endist
\istroot(A3)(3-1) \istb \istb \endist
\cntmAistb
\istrootcntm(4)(A3-2) \istb \endist
\istroot(A4)(4-1) \istb \istb \endist
\end{istgame}
\end{verbatim}

In the example below, \texttt{xtHideEndPoints} and \texttt{xtHidePoints*} cooperatively turn off the effects of \texttt{xtShowEndPoints*} and \texttt{cntmAistb*}.

\begin{verbatim}
\begin{istgame}
\cntdistance*{8mm}{16mm}
\xtShowEndPoints*[oval node]
\cntmAistb*
\istrootcntmA(1) \istb\A \endist
\istroot(A1)(1-1) \istb \istb \istb \endist
\xtShowEndPoints*[box node]
\cntmAistb
\istrootcntmA(2)(A1-2) \istb\A \endist
\istroot(A2)(2-1) \istb \istb \endist
\cntmAistb
\istrootcntmA(3)(A2-2) \istb\A \endist
\istroot(A3)(3-1) \istb \istb \endist
\cntmAistb*
\xtHideEndPoints* \% turns off only cntm endpoints
\xtHideEndPoints
\istrootcntmA(4)(A3-2) \istb\A \endist
\istroot(A4)(4-1) \istb \istb \endist
\end{istgame}
\end{verbatim}
11.5 Information sets for continua of branches

11.5.1 Information sets for continuum triangles

It is not an issue to draw information sets for continuum triangles. You can just apply \xtInfoset or \xtInfosetO.

\begin{istgame}
\cntmdistance*{8mm}
\cntmpreset{1}[green]
\istrootcntm(1) \istb \endist
\xtInfoset([yshift=-1mm]cntm-1)([yshift=-1mm]cntm-2)
\istroot(A1)(1-1) \istb \istb \endist
\istrootcntm(2)(A1-2) \istb \endist
\xtInfoset[fill=red,opacity=.4](cntm-1)(cntm-2)
\istroot(A2)(2-1) \istb \istb \endist
\end{istgame}

11.5.2 \cntmAInfoset for continuum arcs

The macro \cntmAInfoset draws an arc to represent an information set for an arc type continuum of branches, on the background layer. The default position of the arc information set is $1+1$, meaning that $1$ (by default) is added to the position ($1$ by default) of a continuum arc. It must be used right after the corresponding \istrootcntmA whose root coordinate is its mandatory argument. It does not have an option for an information set owner. (If needed, you can use supplementary macros such as \xtInfosetOwner and \xtOwner.)

\begin{istgame}[scale=1.5]
\istrootcntmA(0) \istb \endist
\cntmAInfoset*[<line opt>](<cntm root>)<plot factor>{<addto cntmApos>}
\end{istgame}

% syntax: \cntmAInfoset
% \cntmAInfoset*[<line opt>](<cntm root>)<plot factor>{<addto cntmApos>}
% defaults: (<cntm root>) is mandatory
% [](<m>)<1.333>{.1}

You can change, if necessary, the curvature of an information set arc by using plot factor ($<1.333>$ by default).

% Example: \cntmAInfoset
\begin{istgame}[scale=1.5]
\istrootcntmA(0)
\istb \endist
\cntmAInfoset*(0){-.1}
\cntmAInfoset(0)
\cntmAInfoset[blue,dashed,thick](0){.2}
\end{istgame}

% Example: \cntmAInfoset
\begin{istgame}[scale=1.5]
\istrootcntmA(0)
\istb \endist
\cntmAInfoset[red,dashed,thick](0){-.1}
\cntmAInfoset(0)
\cntmAInfoset[blue,dashed,thick](0){.2}
\end{istgame}

You can also change the position and the line style of an information set arc, as shown in the following example:
11.5.3 \cntmAInfosetO: oval version

The oval version \cntmAInfosetO enables you to draw a bubble type information set for a continuum arc. It must be used right after a simple tree with the root produced by \istrootcntmA and accepts the root of the continuum as the mandatory argument. \cntmAInfosetO can control the style of the information set and height (or thickness), but it does not have an option for the owner of an information set.

% syntax: \cntmAInfosetO
\cntmAInfosetO[line opt]<cntm root>
<plot factor>{<addto cntmApos>[<turn X-ang>]{<infoset height>}}
% defaults: (<cntm root>) is mandatory
[]{(cm)<1.333>{.1}{0}{1em)}

\begin{istgame}[scale=1.2]
\istrootcntmA(0) \istbA \endist
\cntmAInfosetO(0)
\xtdistance{10mm}{20mm}
\istroot(1)(0-1) \istb \istb \endist
\end{istgame}

You can change the style of an information set by using usual TikZ options. You can also change its position and curvature via \cntmApreset.

\begin{istgame}[scale=1.2]
\cntmdistance*{10mm}{20mm}
\istrootcntmA(0) \istbA \endist
\cntmAInfosetO[blue,dashed,thick](0)
\cntmApreset{.6}
\istrootcntmA(1)(0-1) \istbA \endist
\cntmAInfosetO[blue,dashed,thick](1)(.5em)
\cntmApreset{1.8}{.6}
\istrootcntmA(2)(1-1) \istbA \endist
\cntmAInfosetO[fill=blue!20](2)
\end{istgame}

You do not need to bother if a tree is swapped or rotated. Note also that the height (or thickness) of information set are not affected by TikZ scaling.

\begin{istgame}[scale=.8]
\setistgrowdirection'{east}
\cntmdistance*{10mm}{20mm}
\istrootcntmA(0) \istbA \endist
\cntmAInfosetO[blue,dashed,thick](0)
\cntmApreset{.6}
\istrootcntmA(1)(0-1) \istbA \endist
\cntmAInfosetO[solid,fill=green](1)(.5em)
\cntmApreset{1.8}{.6}
\istrootcntmA(2)(1-1) \istbA \endist
\cntmAInfosetO[fill=blue!20](2)
\end{istgame}

If necessary, you can use the turn X-angle option to get a better result (see the following Section 11.5.4 for this issue).
11.5.4 Fine-tuning \cntmAInfosetO: Not for most users

turing X circles

In the case of a severely asymmetrical TikZ scale (using xscale and yscale asymmetrically), an information set drawn by \cntmAInfosetO will probably be distorted, as shown in the upper part of the example below. The bracket option to be used after the mandatory argument of \cntmAInfosetO can solve this problem by turning the blue circle (called, an X circle) drawn at the beginning point of the information set. To do that, specify an appropriate degree of rotation in brackets, like \cntmAInfosetO(2)[60], as shown below. (See Section 10.5.1 for a related topic.)

\begin{example}
\begin{center}
\begin{tikzpicture}
\node at (cntm-1)[draw,circle,blue,opacity=.4,minimum size=1em]{};
\end{tikzpicture}
\end{center}
\end{example}

\begin{example}
\begin{center}
\begin{tikzpicture}
\node at (cntm-1)[draw,circle,blue,opacity=.4,minimum size=1em]{};
\end{tikzpicture}
\end{center}
\end{example}

scaling \cntmAInfosetO according to TikZ scales

The height (or thickness) of an information set drawn by \cntmAInfosetO is not affected by TikZ scales. In some cases, you may want to change the height according to the values of TikZ scales.

As discussed in Section 10.5.2, the \istgame environment treats, for example, \[scale=.7, xscale=1\] and \[scale=.7, xscale=1\] as different, while the tikzpicture environment treats them as equal. With the package \istgame, if you use \[scale=.7, xscale=1\] then the value of scale is not used to keep the height of an oval type information set unchanged, so that you can scale the information set accordingly.

\begin{example}
\begin{center}
\begin{tikzpicture}
\node at (cntm-1)[draw,circle,blue,opacity=.4,minimum size=1em]{};
\end{tikzpicture}
\end{center}
\end{example}

11.6 Transition from obsolete macros \istcntm and \istcntmarc

It turned out to be inconvenient to use the two macros \istcntm and \istcntmarc to express a continuum of branches because it requires two steps. Use, instead, a one step method (if you use only default settings) with \istrootcntm and \istrootcntmA that combine the two steps. Anyway, the two obsolete macros are provided only for backward compatibility with no maintenance and possible to be removed later.

\istcntm The macro \istcntm draws only a background triangle for a continuum of branches. And then you can draw an action taken using \istroot.
\istcntm (obsolete)
\begin{istgame}[scale=1.2]
\istcntm(cntm)
\istroot(0)(cntm){I}\istb{x}[r]\istbm \endist
\xtdistance{10mm}{20mm}
\istroot(1)(0-1){II}\istb{Y}[al]{x,1-x} \istb{N}[ar]{0,0} \endist
\end{istgame}

\istb{N}[ar]{0,0} \endist

\istcntmarc (arc version)
The macro \istcntmarc is the arc version, which draws a back-ground arc to represent a continuum of branches.

\istcntmarc (obsolete)
\begin{istgame}[scale=1.2]
\istcntmarc(cntm)[green]
\istroot(0)(cntm){I}\istb{x}[r]\istbm \endist
\xtdistance{10mm}{18mm}
\istroot(1)(0-1){II}\istb{Y}[al]{x,1-x} \istb{N}[ar]{0,0} \endist
\end{istgame}

The above old way can be switched to the following new way:

\istcntmarc (new way)
\begin{istgame}[scale=1.2]
\istcntmarc(cntm)[green]
\istroot(0)(cntm){I}\istb{x}[r]\istbm \endist
\xtdistance{10mm}{18mm}
\istroot(1)(0-1){II}\istb{Y}[al]{x,1-x} \istb{N}[ar]{0,0} \endist
\end{istgame}

\istb{N}[ar]{0,0} \endist

\istcntmarcA (new way)
\begin{istgame}[scale=1.2]
cnmtApreset<1.44>{.5}[green]
\istrootcntmA(0){I}\istb{x}[r]\istbm \endist
\xtdistance{10mm}{18mm}
\istroot(1)(0-1){II}\istb{Y}[al]{x,1-x} \istb{N}[ar]{0,0} \endist
\end{istgame}

The above old way can be switched to the following new way. One difference is that the position of a continuum arc is now 1 by default, while it was .5.

\istrootcntmA (new way)
\begin{istgame}[scale=1.2]
cnmtApreset<1.44>{.5}[green]
\istrootcntmA(0){I}\istb{x}[r]\istbm \endist
\xtdistance{10mm}{18mm}
\istroot(1)(0-1){II}\istb{Y}[al]{x,1-x} \istb{N}[ar]{0,0} \endist
\end{istgame}
12 Arrows

12.1 Using Ti\textit{k}Z arrow options with \texttt{istgame}

12.1.1 Ti\textit{k}Z arrow option $\Rightarrow$

The simplest way of printing arrows in a whole game tree is to use the Ti\textit{k}Z option $\Rightarrow$ as an option for the \texttt{istgame} environment. To get the best result, you may want to use $\texttt{xtShowEndPoints}$ together with the option $\Rightarrow$.

\begin{verbatim}
\% Example: arrows
\begin{istgame}[->,scale=.8]
\istroot(0)+15mm..30mm+ \istb \istb \endist
\xtShowEndPoints
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(1-2) \istb \istb \endist
\end{istgame}
\end{verbatim}

For an arrow on an individual branch, you can use arrow options with each $\istb$.

\begin{verbatim}
\% Example: arrows
\begin{istgame}[scale=.8]
\istroot(0)+15mm..30mm+ \istb[->] \istb \endist
\xtShowEndPoints
\istroot(1)(0-1) \istb[->] \istb \endist
\xtHideEndPoints
\istroot(2)(0-2) \istb[<>] \istb[->o>>>o>] \endist
\end{istgame}
\end{verbatim}

12.1.2 Fine-tuning with $\texttt{setistgameshorten}$: Not for most users

Assuming that you do not want the terminal points to be shown, in order to get the best result of arrows you can use the macro $\texttt{setistgameshorten}$, like $\texttt{setistgameshorten{1.3pt}}$, right before the \texttt{istgame} environment. Note that $\texttt{setistgameshorten}$ has a global effect. So, when necessary, you should use the macro within a TeX group.

Remark: (not for most users)

- Internally, the \texttt{istgame} environment checks the existence of the option $\Rightarrow$ and automatically adds $\texttt{shorten >=<keyval>}$ (by default, $0pt$) to the option list as the first entry together with $\Rightarrow$.

- You can do the same thing, without using this macro, by manually adding, for example, $\texttt{[->,shorten =1.3pt]}$ to the list of options.

\begin{verbatim}
% Example: $\texttt{setistgameshorten}$
\setistgameshorten{1.3pt} \% use in a TeX group
\begin{istgame}[->,scale=.8] %\texttt{xtShowEndPoints}
\istroot(0)+15mm..30mm+ \istb \istb \endist
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\istroot(3)(1-2) \istb \istb \endist
\end{istgame}
\end{verbatim}

You should also be aware that, in Ti\textit{k}Z, the options $\texttt{shorten}$ and $\Rightarrow$ affect any lines or curves in the current environment.
12.2 Middle arrows for a branch

With \texttt{\textbackslash istb}, you can print an arrow tip in the middle of a branch by using a new \textit{controllable} arrow tip style $\texttt{\textbackslash istb[\rightarrow]}$, like \texttt{\textbackslash istb[\rightarrow]}.

12.2.1 A middle arrow for each \texttt{\textbackslash istb}

To print an arrow tip in the middle of a branch, you can use $\rightarrow$ as an option for \texttt{\textbackslash istb}. The \textit{controllable} middle arrow style $\rightarrow$ takes one optional value, which is a number between 0 and 1 (by default $\rightarrow=.55$) determining a relative position from a parent node to a child node, where the end of an arrow tip is placed. For example, \texttt{\textbackslash istb[\rightarrow=0.1]} prints an arrow tip near the parent node, and \texttt{\textbackslash istb[\rightarrow=0.9]} near the child node.

% Example: new style: middle arrow tip
\begin{istgame}[scale=.8]
\istroot(0)+15mm..30mm+
\istb[\rightarrow] \istb[\rightarrow] \endist
\istroot(1)(0-1)
\istb[\rightarrow=.3] \istb[\rightarrow=.9] \endist
\istroot(2)(0-2)
\istb[\rightarrow=.7,\text{draw=blue}] \istb[\rightarrow=.2,\text{draw=red}] \endist
\istroot(3)(1-2)
\istb \istb[\rightarrow=1] \endist
\end{istgame}

Remark: issues on middle arrows with \texttt{\textbackslash istB}:

- Middle arrows work well with \texttt{\textbackslash istb}, but the exact position of a middle arrow tip does NOT work very well with \texttt{\textbackslash istB}.
- So, if you want to print dual labels for branches with middle arrows, it is recommended to use \texttt{\textbackslash istb} together with \texttt{\textbackslash xtActionLabel}, instead of \texttt{\textbackslash istB} (see also page 25).

Except for \texttt{\textbackslash istB}, all the other variants of \texttt{\textbackslash istb} including \texttt{\textbackslash istbA}, \texttt{\textbackslash cntmistb}, and \texttt{\textbackslash cntmAistb} work well with the middle arrow option $\rightarrow$.

12.2.2 Middle arrow tip styles

The package also provides additional styles for middle arrow tips, which have a \textit{fixed} position and shape. (Note that the single arrow tip $\rightarrow$ is \textit{controllable}.)

Additional middle arrow tip styles:

- $\texttt{\rightarrow\rightarrow\rightarrow}$: double arrow tip in the middle of a branch at the position of .6
- $\texttt{\rightarrow\rightarrow\rightarrow}$: triple arrow tip in the middle of a branch at the position of .65
- $\texttt{\rightarrow\rightarrow\rightarrow}$: circle arrow tip in the middle of a branch at the position of .55
- $\texttt{\rightarrow\rightarrow\rightarrow}$: cross arrow tip in the middle of a branch at the position of .5

Remark: All the middle arrow tips are printed in black, by default. Their color can be changed by \texttt{\textbackslash setxtarrowtips} (see the following Section 12.2.3).

\begin{istgame}[xscale=.8]
\istroot(0)+15mm..30mm+
\istb[\rightarrow] \istb[\rightarrow\rightarrow\rightarrow,red] \endist
\istroot(1)(0-1)
\istb[\rightarrow=.3,\text{red}] \istb[\rightarrow=.9,\text{blue}] \endist
\setxtarrowtips[blue,thick]
\istroot(2)(0-2)
\istb[\rightarrow=.7] \istb[\rightarrow=.2,\text{red}] \endist
\istroot(3)(1-2)
\istb \istb[\rightarrow=1] \endist
\end{istgame}
12.2.3 \setxtarrowtips: controlling middle arrow tips via \texttt{->-}

The macro \texttt{\setxtarrowtips} controls the position and shape of a middle arrow tip, but only works through the \textit{controllable} middle arrow style \texttt{->-}, not the other \textit{fixed} arrow styles. However, it controls the color of \textit{all} the middle arrow tips. The effect of change by this macro continues until the end of the current environment unless it is changed again. To restore the default values, just declare \texttt{\setxtarrowtips} followed by nothing.

\begin{quote}
\texttt{\% \setxtarrowtips
\% syntax: all arguments are optional
\setxtarrowtips\langle midarrow tip pos\rangle\langle arrow shape\rangle\langle arrow opt\rangle
\% defaults: <.55>{>}[black,-,thin,solid,shorten >=0pt]
\}
\end{quote}

\begin{quote}
\texttt{\%
\% Example: \setxtarrowtips
\begin{istgame}[scale=1]
\setxtarrowtips<.9>{>>}[blue,thick]
\istroot(0)+15mm..25mm+ \istb[->-]\istb[->-] \endist
\istroot(1)(0-1) \istb[->-=.5]\istb[->-=.3] \endist
\setxtarrowtips<.9>{<lo>}[blue,thick,opacity=.4]
\istroot(2)(0-2) \istb[->-=green]\istb[->-=red] \endist
\setxtarrowtips<.7>
\istroot(3)(1-2) \istb[istb[->-]] \endist
\istroot(4)(2-2) \istb[-o-]\istb[-x-] \endist
\end{istgame}
\}
\end{quote}

Note that, as seen in the example above, the position set individually by an option value of \texttt{\istb}, like \texttt{\istb[->-=.3]}, wins the position set by \texttt{\setxtarrowtips<.9>}.

12.3 Middle arrow for simple trees

12.3.1 \xtShowMidArrows and \xtHideMidArrows

The macro \texttt{\xtShowMidArrows} prints \textit{middle arrows} (a single arrow tip, by default) for \textit{all the branches} of a \textit{simple tree} (but not for a separate branch). The effect of \texttt{\xtShowMidArrows} continues until it is changed by another \texttt{\xtShowMidArrows} or blocked by \texttt{\xtHideMidArrows}.

\begin{quote}
\texttt{\%
\% Example: \xtShowMidArrows, \xtHideMidArrows
\begin{istgame}
\xtShowMidArrows
\istroot(0)+15mm..30mm+ \istb[blue]\istb[red] \endist
\xtHideMidArrows
\istroot(1)(0-1) \istb \istb \endist
\istroot(2)(0-2) \istb \istb \endist
\xtShowMidArrows
\istroot(3)(1-2) \istb \istb \endist
\end{istgame}
\}
\end{quote}

Remark:
- \texttt{\xtShowMidArrows} works for all branches of simple trees.
- The middle arrow option styles work separately only for \texttt{\istb’s} having them and \texttt{\setxtarrowtips} works only for \texttt{\istb’s} having the option \texttt{\texttt{-}-}.  

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• Since the middle arrow tip styles and `\xtShowMidArrows` work completely independently, if you use both of them, they are all printed.

• Note also that `\xtHideMidArrows` removes only the effect of `\xtShowMidArrows`.

\begin{lstlisting}[language=TeX]
\begin{istgame}
\setxtarrowtips<.3>{*}{red}
\xtShowMidArrows
\istroot{0}+15mm..30mm+ \istb[blue] \istb[red] \endist
\xtHideMidArrows
\istroot{1}(0-1) \istb[->-] \istb[-o-] \endist
\xtShowMidArrows
\istroot{2}(0-2) \istb \istb \endist
\istroot{3}(1-2) \istb[->-] \istb[-o-] \endist
\end{istgame}
\end{lstlisting}

12.3.2 `\setxtshowmidarrows`: controlling `\xtShowMidArrows`

The macro `\setxtshowmidarrows`, you can control the position, color, style, and shape of middle arrow tips, to be drawn by `\xtShowMidArrows`.

\begin{lstlisting}[language=TeX]
\begin{istgame}
\setxtshowmidarrows
\begin{istgame}
\xtShowMidArrows
\setxtshowmidarrows\text{<midarrow tip relative pos>=<arrow shape>}[<arrow opt>]
\setxtshowmidarrows\text{<.55>=[>][red,thick]}
\end{istgame}
\end{istgame}
\end{lstlisting}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{example}
\caption{Example of `\setxtshowmidarrows`}
\end{figure}

Remark: issues in adding other graphic objects (not for most users)

• As you can see in the above example, when `\xtShowMidArrows` is used, you should redefine coordinates for endpoints before you use them for other graphic objects.

• This is because, in Ti\textsc{k}Z, \texttt{shift} or \texttt{scope} does not work in this case. So, alternatively, you can use \texttt{\draw [transform canvas={yshift=-5pt}] (2-1) -- (2-2);} (See Ti\textsc{k}Z manual about \texttt{transform canvas}).

• `\xtShowArrows` does not affect the Ti\textsc{k}Z absolute coordinates.
12.4 Arrows for simple trees

12.4.1 \texttt{\textbackslash xtShowArrows} and \texttt{\textbackslash xtHideArrows}

In many cases you might not need to care about the position of arrow tips, just wanting to put them at the ends of branches for simple trees. For this purpose, the macro \texttt{\textbackslash xtShowArrows} (accepting one bracket option for a node style) is provided.

\texttt{\textbackslash xtShowArrows}, internally, calls \texttt{\textbackslash xtShowEndPoints} (with \texttt{\textbackslash solid node}, by default) first and then prints arrows in order to produce the best result of showing arrows. So, for example, \texttt{\textbackslash xtShowArrows[\texttt{\textbackslash oval node}]} is equivalent to \texttt{\textbackslash xtShowEndPoints[\texttt{\textbackslash oval node}]} followed by printing of arrows (in black by default).

The macro \texttt{\textbackslash xtHideArrows} turns off all the effect of \texttt{\textbackslash xtShowArrows}, while \texttt{\textbackslash xtHideArrows*} has the endpoints remained. (\texttt{\textbackslash xtShowArrows} does not have its starred version.)

\begin{verbatim}
% Example: \texttt{\textbackslash xtShowArrows, \textbackslash xtHideArrows}
\begin{istgame}
\xtShowArrows
\istroot(0)+15mm..30mm+ \istb[blue] \istb[red] \endist
\xtHideArrows
\istroot(1)(0-1) \istb[a] \istb \endist
\xtHideArrows* \% endpoints remain
\istroot(2)(0-2) \istb[b] \istb \endist
\xtShowArrows[\texttt{\textbackslash oval node}]
\istroot(3)(1-2) \istb[c] \istb \endist
\end{istgame}
\end{verbatim}

Remark: issues in adding other graphic objects (not for most users)

- Like \texttt{\textbackslash xtShowMidArrows}, when \texttt{\textbackslash xtShowArrows} is used, you should redefine coordinates for endpoints before you use them for other graphic objects, or use \texttt{transform canvas}.

12.4.2 \texttt{\textbackslash setxtshowarrows}: controlling \texttt{\textbackslash xtShowArrows}

The macro \texttt{\textbackslash setxtshowarrows} controls the color and shape of arrow tips. You can even change the position of arrow tips by specifying the distance (1.2pt by default) from the endpoint as the last parenthesis optional argument, like \texttt{(5pt)}.

\begin{verbatim}
\% \texttt{\textbackslash setxtshowarrows}
\% syntax:
\% \texttt{\textbackslash setxtshowarrows[\texttt{\langle arrow opt\rangle}}{\langle arrow shape\rangle}{\langle arrow end shorten dim\rangle})
\% defaults: \texttt{[]}\langle\rangle(1.2pt)
\% Example: \texttt{\textbackslash xtShowArrows, \textbackslash xtHideArrows}
\begin{istgame}
\setxtshowarrows\{<>\}{\langle|o|\rangle}{blue,thick}(5pt)
\xtShowArrows
\istroot(0)+15mm..30mm+ \istb[blue] \istb[red] \endist
\xtHideArrows
\istroot(1)(0-1) \istb[a] \istb \endist
\xtHideArrows* \% endpoints remain
\istroot(2)(0-2) \istb[b] \istb \endist
\xtShowArrows[\texttt{\textbackslash oval node}]
\istroot(3)(1-2) \istb[c] \istb \endist
\end{istgame}
\end{verbatim}
12.4.3 Arrows and continua of branches: examples (Not for most users)

There is nothing special in using arrow tips in game trees having continua of branches.

\begin{istgame}[font=\scriptsize]
\xtdistance{10mm}{20mm}
\xtShowArrows
\istrootcntm(0)(0,0){1} \istb{x}[x] \istbm \endist
\istroot(1)(0-1){[label distance=-3pt]120>{2}} \istb{Y}[al]{x,1-x} \istb{N}[ar] \endist
\istrootcntm(2)(1-2){2} \istb{y}[z] \istbm \endist
\istroot(3)(2-1){[label distance=-3pt]120>{1}} \istb{Y}[al]{1-y,y} \istb{N}[ar] \endist
\end{istgame}

It is not impossible to put arrow tips on the outermost branches of a continuum. To do that, you can use \cntmistb(*) and \cntmAistb(*) together with the middle arrow tip styles and \setxtarrowtips.

\begin{istgame}[font=\scriptsize]
\xtdistance{10mm}{20mm}
\xtShowArrows
\setxtarrowtips<.97>
\cntmistb*[-,-,draw]
\istrootcntm(0)(0,0){1} \istb{x}[x] \istbm \endist
\istroot(1)(0-1){[label distance=-3pt]120>{2}} \istb{Y}[al]{x,1-x} \istb{N}[ar] \endist
\istrootcntm(2)(1-2){2} \istb{y}[z] \istbm \endist
\istroot(3)(2-1){[label distance=-3pt]120>{1}} \istb{Y}[al]{1-y,y} \istb{N}[ar] \endist
\end{istgame}

Here is one more example.

\begin{istgame}
\cntdistance*{8mm}{16mm}
\xtShowEndPoints*[oval node]
\setxtarrowtips*.93>{>>}[red,thick]
\cntmAistb*[-,-]
\istrootcntmA(1) \istbA[-x-] \endist
\istroot(A1)(1-1) \istb \istb \endist
\cntmAistb*[-,-]
\istrootcntmA(2)(A1-2) \istbA[-o-] \endist
\istroot(A2)(2-1) \istb \istb \endist
\setxtarrowtips*.93>
\cntmAistb*[-,-]
\istrootcntmA(3)(A2-2) \istbA[-x-] \endist
\istroot(A3)(3-1) \istb \istb \endist
\cntmAistb*[-,-]
\istrootcntmA(4)(A3-2) \istbA[-o-] \endist
\istroot(A4)(4-1) \istb \istb \endist
\end{istgame}
13 Supplementary macros

13.1 Supplementary macros to important labels

The istgame package also provides some supplementary macros to important labels: players, action labels, and payoffs. The supplementary macros work outside of simple trees.

\xtOwner puts the owner of a node (or a player), in text mode
\xtOwner* puts an owner in the input mode as set by \setistmathTF(*)
   syntax: \xtOwner(<coor>){<owner>}[<pos>,<node opt>]
   defaults: \{<m>\}[above]
   (abbreviations for <pos> available)
\xtActionLabel puts an action label to a branch, in math mode
\xtActionLabel* puts an owner in the input mode as set by \setistmathTF(*)
   syntax: \xtActionLabel[<opt>](<from>)(<to>){<action>}[<pos>,<node opt>]
   defaults: \{-,draw=none\}(<m>)(<m>){}\[black,text depth=.25ex]
   (abbreviations for <pos> available)
\xtPayoff puts payoffs, in math mode
\xtPayoff* puts payoffs in the input mode as set by \setistmathTF(*)
   syntax: \xtPayoff(<coor>){<payoff>}[<pos>,<node opt>]
   defaults: \{(m)\}{}\[inner sep=0pt,outer sep=4pt,text depth=.25ex]
   (abbreviations for <pos> available)
\xtInfosetOwner puts the owner of an information set, in text mode
\xtInfosetOwner* puts an information set owner in the input mode as set by \setistmathTF(*)
   syntax: \xtInfosetOwner(<from>)(<to>){<owner>}[<pos>,<node opt>]
   defaults: \{(m)\}(<m>)\{\}
   (abbreviations for <pos> available)
\xtNode puts 'something,' say an owner, into a node
   syntax: \xtNode[<opt>](<coor>)[<node style>,<node opt>]{<node text>}
   defaults: \{-\}(<m>)\{solid node\}{}
\xtNode* puts 'something' into a plain node
   syntax: \xtNode*(<coor>)[<node style>,<node opt>]{<node text>}
   defaults: \{<m>\}[plain node]{}

The supplementary macros depend on the coordinates defined in the sequence of \istroot–\istb–\endist and print their corresponding objects on or around the specified coordinates. So, in the above supplementary macros, all the coordinates such as \(<from>\), \(<to>\), and \(<coor>\) are mandatory arguments, denoted by \(<m>\).

\begin{istgame}[scale=1.5]
\istroot(0)[chance node]
   \istb[dashed](4) \istb*
   \istb*[blue,very thick]B\{right,xshift=2pt,yshift=2pt,red\}
\endist
\xtInfosetO(0,0)
\xtInfoset[thick](0-1)(0-2){1}
\xtInfoset[thick,red,rounded corners=.5em](0-2)(0-3){2}
\xtInfoset[dashed,bend right=25](0-1)(0-3)
\xtActionLabel(0-3){1-\textbackslash\textepsilon}{below,sloped} \% action label in math mode
\xtInfosetOwner(0-1)(0-3){3}[xshift=-25pt,yshift=-25pt]
\xtOwner(0){Nash}[xshift=-5pt,left]
\xtPayoff(0-3){(u_1, u_2)}[right,xshift=5pt] \% payoffs in math mode
\xtNode[dotted](0-1){Box node,fill=blue!20}{Smith}
\xtNode*{(a-1)}{text}
\end{istgame}
To specify the \<pos>\] option for the above supplementary macros (other than \xtNode\), you can use the abbreviations \l, \r, \a, \b, \al, \ar, \bl, and \br. Each of these abbreviations works only when used alone without any other option keys in the option list. For example, the option \b or \below or \below,xshift=5pt\ works, but \b,xshift=5pt\ does not, producing a compile error.

13.2 More supplementary macros

13.2.1 \xtTimeLineH and \xtTimeLineV

With the macro \xtTimeLineH, you can draw a horizontal time-line.

\begin{verbatim}
\\xtTimeLineH (same logic for \xtTimeLineV)
\% syntax: \% if tree swapped, the following means <-from> <-to>
\\xtTimeLineH[<opt>]<coor>;<from>;<to>;<label>[<pos>,<opt>] \[right
\% defaults: 
\[-,dotted,shorten <=0pt,shorten >=0pt]<coor>{};<from>;<to>{}\[right

\end{verbatim}

For example, \xtTimeLineH(coor){-1.5}{3} draws a dotted (by default) horizontal time-line going through (coor) from -1.5cm to 3cm with a label on the right (by default). Recall that, by default, the root of a tree is located at (0,0). The two numbers determine the x-coordinates of a time-line. To change the position of the label, you can use the abbreviations, like \a or \ar.

The swap version \xtTimeLineH' simply puts the label on the other end of a time-line, \left by default. That's the only difference to the normal version, \xtTimeLineH.

Remark: The direction to which a time-line goes depends on whether a tree is swapped or not.

- If branches are arranged \texttt{counterclockwise} (by default), a time-line goes from \texttt{left} to \texttt{right} or from \texttt{below} to \texttt{above}. As to \xtTimeLineH, we take this as a standard case: \texttt{left to right}.
- If a tree is \texttt{swapped}, so the branches are arranged \texttt{clockwise}, \xtTimeLineH draws a line going to the opposite direction: \texttt{from right to left} (for trees growing southwards). So, if a tree is swapped by \setistgrowdirection', for example, \xtTimeLineH(coor){-1.5}{3} draws a time-line going the to the opposite direction: from 1.5cm to -3cm.
The following codes are the same as the above, except that the tree is swapped.

% Example: \xtTimeLineH: swapped
\begin{istgame}[font=\scriptsize]
\setistgrowdirection '{south} % clockwise 
\xtdistance{10mm}{20mm}
\istrootcntm(1) \istb \istbm \endist 
\istroot(A1)(1-1) \istb \istb \endist 
\istrootcntm(2) (A1-2) \istb \istb \endist 
\istroot(A2)(2-1) \istb \istb \endist 
\istrootcntm(3) (A2-2) \istb \istb \endist 
\istroot(A3)(3-1) \istb \istb \endist 
\xtTimeLineH[-] (1){-1.5}{3}{period 1} 
\xtTimeLineH(2){-1.5}{3}{period 2} 
\xtTimeLineH'(3){-1.5}{3}{period 3} 
\end{istgame}

With the macro \xtTimeLineV, you can draw a vertical time-line with a label on the top right, by default. As to \xtTimeLineV, we take a time-line going from above to below as a standard case, because it is natural. So, if a tree grows eastwards, the swapped tree (arranging branches from above to below) is taken as a standard case for \xtTimeLineV.

The swap version \xtTimeLineV' simply puts the label on the other side of a time-line. That’s the only difference to the normal version, \xtTimeLineV.

% Example: \xtTimeLineV('): swapped
\begin{istgame}[font=\scriptsize]
\setistgrowdirection '{east} % clockwise 
\xtdistance{10mm}{20mm}
\istrootcntm(1) \istb \istbm \endist 
\istroot(A1)(1-1) \istb \istb \endist 
\istrootcntm(2) (A1-2) \istb \istb \endist 
\istroot(A2)(2-1) \istb \istb \endist 
\istrootcntm(3) (A2-2) \istb \istb \endist 
\istroot(A3)(3-1) \istb \istb \endist 
\xtTimeLineV(->)(1){1.5}{-3}{period 1} 
\xtTimeLineV(2){1.5}{-3}{period 2} 
\xtTimeLineV'(3){1.5}{-3}{period 3} 
\end{istgame}

The following codes are the same as the above, except that the tree is not swapped.

\begin{istgame}[font=\scriptsize]
\setistgrowdirection '{east} % counterclockwise 
\xtdistance{10mm}{20mm}
\istrootcntm(1) \istb \istbm \endist 
\istroot(A1)(1-1) \istb \istb \endist 
\istrootcntm(2) (A1-2) \istb \istb \endist 
\istroot(A2)(2-1) \istb \istb \endist 
\istrootcntm(3) (A2-2) \istb \istb \endist 
\istroot(A3)(3-1) \istb \istb \endist 
\xtTimeLineV(->)(1){1.5}{-3}{period 1} 
\xtTimeLineV(2){1.5}{-3}{period 2} 
\xtTimeLineV'(3){1.5}{-3}{period 3} 
\end{istgame}

In the example above, since the tree is not swapped, \xtTimeLineV(\text{coor}){1.5}{-3} draws a vertical time-line going to the opposite direction: from -1.5cm to 3cm.
13.2.2 \texttt{\textit{\texttt{xtCommentTo}} and \texttt{\textit{\texttt{xtCommentFrom}}}}

With the macro \texttt{\textit{\texttt{xtCommentTo}}}, you can attach a comment to a node from a coordinate \textit{relative} to the node with a densely dotted arrow line (by default). Note that with \texttt{\textit{\texttt{xtCommentTo}} you need to specify a target \textit{absolute} coordinate followed by a start \textit{relative} coordinate.

\begin{verbatim}
% \texttt{\textit{\texttt{xtCommentTo}}}
% syntax: \texttt{\textit{\texttt{xtCommentTo}}[<line opt>](<absolute to-coor>)(<relative from-coor>){<comment>}}
% [<pos>,<node opt>][<end-shorten dim>]
% defaults: [densely dotted,->,>=stealth,shorten >=1pt](<m>)(<m>){}
% [above](1pt)
\end{verbatim}

The last parenthesis option if for shortening arrow end. You can use the abbreviations of the directional words, but not with other options in the option list.

\begin{verbatim}
% Example: \texttt{\textit{\texttt{xtCommentTo}}}
\begin{istgame}|->,scale=.7|
\xtShowEndPoints
\istroot(0)+15mm..30mm+  \istb  \istb  \endist
\istroot(1)(0-1)        \istb  \istb  \endist
\istroot(2)(0-2)[chance node] \istb  \istb  \endist
\xtCommentTo[bend right](0)(150:2){Alice moves}[1]
\xtCommentTo[bend right](1)(150:2){Ben moves}
\xtCommentTo[bend left](2)(0,2){Nature moves}[a](5pt)
\end{istgame}
\end{verbatim}

The macro \texttt{\textit{\texttt{xtCommentFrom}}} enables you to attach a comment to one or more nodes from an \textit{absolute} coordinate with a densely dotted arrow line. Note that with \texttt{\textit{\texttt{xtCommentFrom}}} you need to specify a \textit{start absolute} coordinate followed by a \textit{target absolute} coordinate. The last parenthesis option if for shortening arrow end. You can use the abbreviations of the directional words.

\begin{verbatim}
% \texttt{\textit{\texttt{xtCommentFrom}}}
% syntax: \texttt{\textit{\texttt{xtCommentFrom}}[<line opt>](<from>)(<to>){<comment>}}<arrow end shorten>
% defaults: [densely dotted,->,>=stealth,shorten >=1pt](<m>)(<m>){}[above](1pt)
\end{verbatim}

\begin{verbatim}
% Example: \texttt{\textit{\texttt{xtCommentFrom}}}
\begin{istgame}[scale=.6]
\xtShowEndPoints
\istb \istb \endist
\istroot(0)+15mm..30mm+  \istb  \istb  \endist
\istroot(1)(0-1)        \istb  \istb  \endist
\istroot(2)(0-2)[chance node] \istb  \istb  \endist
\xtCommentFrom[bend right,blue,-3,2](0){decision nodes}
\xtCommentFrom[bend right](3,2)(1)
\xtCommentFrom[bend right,solid,blue,-3,2](2)
\xtCommentFrom[bend right,-3,5](1-1){terminal nodes}[b]
\xtCommentFrom[bend right,-3,5](1-2)
\xtCommentFrom[bend right,-3,5](2-1)
\xtCommentFrom[bend right,-3,5](2-2)(5pt)
\end{istgame}
\end{verbatim}
14 Representing subgames

Here is an example of a whole game tree.

\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[initial node]<0>{1}
\istb(A)[a]{(2,2)}{[1]}
\istb(D)[r] \endist
\istroot(1)(0-2)<135>{1}
\istb(L)[al]
\istb(R)[ar] \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb(ell)[al]{(4,2)} \istb(r)[ar]{(1,1)} \endist
\istroot(3)(1-2)<45>{2}
\istb(ell)[al]{(3,2)} \istb(r)[ar]{(0,3)} \endist
\end{istgame}

14.1 \xtSubgameBox (experimental)

\xtSubgameBox

\xtSubgameBox is for indicating a subgame by a box (or a rectangle) with rounded corners.

% \xtSubgameBox(*)
% syntax:
% \xtSubgame(*){(subroot coor)}{(coor1) (coor2) ... }[opt]
% options:
% *: filled box
% (subroot(1) ...): the subroot of a subgame (mandatory)
% {(coor1) (coor2) ...}: coordinates of terminal nodes (mandatory)
% [opt]: color, line style
% defaults:
% (*{<m>}){rectangle,dashed,inner sep=20pt,rounded corners=15pt,black!50}
% *(<m>){rectangle,inner sep=20pt,rounded corners=15pt,red!20}

The subgame box embraces the subroot indicated in parentheses and terminal nodes specified within curly braces. The coordinates of terminal nodes are listed in curly braces without delimiters (spaces are allowed). The default options for the subgame box are dashed, inner sep=20pt, rounded corners=15pt, and black!50.

\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[initial node]<0>{1}
\istb(A)[a]{(2,2)}{[1]}
\istb(D)[r] \endist
\istroot(1)(0-2)<135>{1}
\istb(L)[al]
\istb(R)[ar] \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb(ell)[al]{(4,2)} \istb(r)[ar]{(1,1)} \endist
\istroot(3)(1-2)<45>{2}
\istb(ell)[al]{(3,2)} \istb(r)[ar]{(0,3)} \endist
\xtSubgameBox(1){(2-1)(3-2)}
\xtSubgameBox(2){(2-1)(2-2)}{solid,blue}
\end{istgame}
You can change the size of the box in two ways. First, you can change it by using `inner sep`, `inner xsep`, or `inner ysep`. Secondly, you can shift the subroot, like `\[xshift=5pt\]` when the subroot is `(1)`. Of course, you can do the both at the same time.

\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0) [initial node]<0>{1}
\endist
\istroot(1)(0-2)<135>{1}
\endist
\istb{A}[al] \istb{D}[ar] \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{\ell}{al}{(4,2)} \istb{r}{ar}{(1,1)} \endist
\istroot(3)(1-2)<135>{2}
\istb{\ell}{al}{(3,2)} \istb{r}{ar}{(0,3)} \endist
\xtSubgameBox{(2-1)(3-2)}\%
\[solid,blue,inner sep=10pt\]
\end{istgame}

14.1.2 \xtSubgameBox*

The starred version \xtSubgameBox* produces a subgame box with background color (by default red!20). In the following example, where the tree grows east, the size of the filled subgame box is adjusted by manipulating `inner sep` and `xshift`.

\begin{istgame}
\setistgrowdirection'{east}
\xtdistance{15mm}{30mm}
\istroot[45](0) [initial node]<180>{1}
\endist
\istroot(1)(0-2)<135>{1}
\endist
\istb{L}[al] \istb{R}[bl] \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{\ell}{al}{(4,2)} \istb{r}{bl}{(1,1)} \endist
\istroot(3)(1-2)<135>{2}
\istb{\ell}{al}{(3,2)} \istb{r}{bl}{(0,3)} \endist
\xtSubgameBox*[\[xshift=20pt\]2]{(2-1)(3-2)}\%
\[inner xsep=30pt\]
\end{istgame}

14.2 \xtSubgameOval and \xtSubgameOval* (experimental)
\xtSubgameOval and \xtSubgameOval* are also provided.

% \xtSubgameOval(*)
% \syntax:
% \xtSubgameOval(*)(<subroot coor>){(<coor1>) (<coor2>) ... }[<opt>]
% \options:
% *: filled box
% (<subroot coor>): the subroot of a subgame (mandatory)
% {<coor1> (<coor2> ... }): coordinates of terminal nodes (mandatory)
% [<opt>]: color, line style
% \defaults:
% (<m>){}[ellipse,dashed,inner sep=20pt,rounded corners=15pt,black!50]
% (*<m>){}[ellipse,inner sep=20pt,rounded corners=15pt,red!20]
\texttt{\textbackslash xtSubgameOval(*)} works just like \texttt{\textbackslash xtSubgameBox(*)}, except for one thing: an oval instead of a rectangle. \texttt{\textbackslash xtSubgameOval} draws an oval (or an ellipse) to represent a subgame, and \texttt{\textbackslash xtSubgameOval*} draws a filled oval with \texttt{red!20} by default.

The way of changing the size of the subgame oval is the same as with \texttt{\textbackslash xtSubgameBox}: first, changing inner sep, and secondly, shifting the subroot. In the example below, the options \texttt{inner xsep=25pt} and \texttt{([xshift=30pt]1)} are used to change the size of the subgame oval. Its color is changed by \texttt{blue!20}.

\begin{verbatim}
\% subgame: ellipse
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0){initial node}<0>{1}
\istb{A}[a]{{(2,2)}[1]}
\istb{D}[r]
\endist
\istroot(1)(0-2)<135>{1}
\istb{L}[a]
\istb{R}[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{ell}[al]{{{(4,2)}
\istb{r}[ar]{{{(1,1)}
\endist
\istroot(3)(1-2)<45>{2}
\istb{ell}[al]{{{(3,2)}
\istb{r}[ar]{{{(0,3)}
\endist
\xtSubgameOval(1){{{(2-1)(3-2)}
\xtSubgameOval(2){{{(2-1)(2-2)}
\end{istgame}
\end{verbatim}

\begin{verbatim}
\% subgame: ellipse*
\begin{istgame}
\setistgrowdirection'\{east\}
\xtdistance{15mm}{30mm}
\istroot[45](0){initial node}<180>{1}
\istb{A}[a]{{(2,2)}[a]}
\istb{D}[b]
\endist
\istroot(1)(0-2)<135>{1}
\istb{L}[al]
\istb{R}[ar]{{(0,3)}
\endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{ell}[al]{{{(4,2)}
\istb{r}[ar]{{{(1,1)}
\endist
\istroot(3)(1-2)<-135>{2}
\istb{ell}[al]{{{(3,2)}
\istb{r}[ar]{{{(0,3)}
\endist
\xtSubgameOval*{[xshift=30pt]1}{{{(2-1)(3-2)}% [inner xsep=25pt,blue!20]
\end{istgame}
\end{verbatim}
14.3 \setxtsubgamelayer

You can change the shape of a subgame representation to other shapes such as semicircle and circle or even star. You will need to change the size of the shape by using \innersep and by shifting the subroot to get the result you want.

Here are more examples showing how to draw a rectangle and circles to represent subgames.

You can use \setxtsubgamelayer to change the layer of a subgame from background to behind, main, above, or foreground, in that order. In order to go back to the default layer, you can just declare \setxtsubgamelayer or do \setxtsubgamelayer{}. 

% subgame: half circle
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[initial node]<0>{1}
\istb{A}{a}{(2,2)}{1}
\istb{D}{r} \endist
\istroot(1)(0-2)<135>{1}
\istb{L}{al}
\istb{R}{ar} \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{ell}{al}{(4,2)}
\istb{r}{ar}{(1,1)} \endist
\istroot(3)(1-2)<45>{2}
\istb{ell}{al}{(3,2)}
\istb{r}{ar}{(0,3)} \endist
\xtSubgameBox{([yshift=-2cm]1)}{((2-1)(3-2))}%
[semicircle,inner sep=15pt]
\end{istgame}

% subgame: rectangle*
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[initial node]<0>{1}
\istb{A}{a}{(2,2)}{1}
\istb{D}{r} \endist
\istroot(1)(0-2)<135>{1}
\istb{L}{al}
\istb{R}{ar} \endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
\istb{ell}{al}{(4,2)}
\istb{r}{ar}{(1,1)} \endist
\istroot(3)(1-2)<45>{2}
\istb{ell}{al}{(3,2)}
\istb{r}{ar}{(0,3)} \endist
\xtSubgameBox*{1}{((2-1)(3-2))}
\xtSubgameOval*{2}{((2-1)(2-2))}%
[circle,blue!20,inner xsep=9pt]
\xtSubgameOval{3}{(3-1)(3-2)}%
[circle,inner xsep=9pt]
\end{istgame}
15 Miscellany

15.1 Various branch types, directions, and lengths

Here is an example of how to deal with various line types, directions, and lengths of branches. You can do this using \istbA (see Section 5.5, for more details).
15.2 Code reuse

15.2.1 Drawing subgames

Suppose that you have the following tree as a whole game.

```latex
\begin{verbatim}
% Example: a whole game
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[initial node]<0>{1}
  \istb(A)[a]{(2,2)}[1]
  \istb(D)[r]
\endist
\istroot(1)(0-2)<left>{1}
  \istb(L)[al]
  \istb(R)[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
  \istb(ell)[al]{(4,2)}
  \istb(r)[ar]{(1,1)}
\endist
\istroot(3)(1-2)<45>{2}
  \istb(ell)[al]{(3,2)}
  \istb(r)[ar]{(0,3)}
\endist
\end{istgame}
```

It is easy to draw a subgame if you use the existing codes for a whole game. To get a subgame, just comment out the codes for the rest of the subgame.

```latex
\begin{verbatim}
% Example: a subgame
\begin{istgame}
\xtdistance{15mm}{30mm}
%\istroot[-135](0)[initial node]<0>{1}
%\istb(A)[a]{(2,2)}[1]
%\istb(D)[r]
\endist
\istroot(1)(0-2)<left>{1}
  \istb(L)[al]
  \istb(R)[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)<135>{2}
  \istb(ell)[al]{(4,2)}
  \istb(r)[ar]{(1,1)}
\endist
\istroot(3)(1-2)<45>{2}
  \istb(ell)[al]{(3,2)}
  \istb(r)[ar]{(0,3)}
\endist
\end{istgame}
```

Remark: If you copy and paste the previous codes alone and try to compile to get a subgame, you will get an error message:

```
! Package pgf Error: No shape named 0-2 is known.
```

This is because the first active \istroot refers to the undefined coordinate (0-2). In this case you need to change the line as:

```
\istroot(1)(0,0)<left>{1}
```
However, if you have the codes for a whole game before the codes with some lines commented out for a subgame, you will not get the error message when you compile the file (because the coordinate (0-2) is already defined in the whole game). Therefore, most of the time you will not get the error message by commenting out some lines to get a subgame.

A smaller subgame is also easy to get by commenting out the rest of the subgame you want.

\begin{example}
\begin{verbatim}
\setistDecisionNodeStyle[black!5]
\end{example}

It is not possible to make a subgame stay put where it appears in a whole game. (Replace [black!5] by [white] to make the rest of the game disappear in the example below.)

\begin{example}
\begin{verbatim}
\setistDecisionNodeStyle[black!5]
\end{example}
15.2.2 Backward induction

It is also easy to illustrate the procedure of backward induction, when you analyze an extensive game.

By using \verb|\istb| with options for the middle arrow tips, you can effectively express the backward induction procedure. The command \verb|\setxtarrowtips| controls the style of arrow tips and just declaring \verb|\setxtarrowtips| followed by nothing restores defaults for the middle arrow tips styles. See Section 12, for more details. change the color and the style of a line representing a branch and an arrow tip to it.
15.2.3 Code reusability

Chen\textsuperscript{(2013)}'s work is good to understand how drawing a game tree with TikZ works.

\begin{tikzpicture}[scale=1,font=\footnotesize]
\tikzstyle{solid node}=[circle,draw,inner sep=1.5,fill=black]
\tikzstyle{hollow node}=[circle,draw,inner sep=1.5]
\tikzstyle{level 1}=[level distance=15mm,sibling distance=3.5cm]
\tikzstyle{level 2}=[level distance=15mm,sibling distance=1.5cm]
\tikzstyle{level 3}=[level distance=15mm,sibling distance=1cm]

\node(0)[solid node,label=above:{$P1$}]{}
child{node[solid node,label=above left:{$P2$}]{}
  child{node[hollow node,label=below:{$(1,2)$}]{} edge from parent node[left]{$C$}}
  child{node[hollow node,label=below:{$(1,-1)$}]{} edge from parent node[left]{$D$}}
  child{node[hollow node,label=below:{$(0,2)$}]{} edge from parent node[right]{$E$}}
  edge from parent node[left,xshift=-5]{$A$}}
child{node[solid node,label=above right:{$P2$}]{}
  child{node[hollow node,label=below:{$(2,2)$}]{} edge from parent node[left]{$F$}}
  child{node[hollow node,label=below:{$(1,3)$}]{} edge from parent node[right]{$G$}}
  edge from parent node[right,xshift=5]{$B$}};
\end{tikzpicture}

You can get a quite similar (actually the same) result by using the \texttt{istgame} package.

\begin{istgame}[scale=1,font=\footnotesize]
\setistDecisionNodeStyle{4pt}
\xtdistance{15mm}{3.5cm}
\istroot(0){$P1$}
  \istb{A}[al]
  \istb{B}[ar]
\endist
\xtShowEndPoints[oval node]
\xtdistance{15mm}{1.5cm}
\istroot(1)(0-1)<135>{$P2$}
  \istb{C}[1]{(1,2)}
  \istb{D}[1]{(1,-1)}
  \istb{E}[r]{(0,2)}
\endist
\istroot(2)(0-2)<45>{$P2$}
  \istb{F}[1]{(2,2)}
  \istb{G}[r]{(1,3)}
\endist
\end{istgame}

The \texttt{istgame} package enhances simplicity and readability, and hence it is easy to reuse codes. You can easily read and modify game tree codes even if you go over them after a while.
16 Game tree examples

This section provides some examples of extensive games. Before we start, let us change the default font size of the istgame environment by stating \texttt{\setistgamefontsize{\footnotesize}} outside of the environment. (Right here!)

16.1 Simple examples

\begin{istgame}[->,shorten >=1.3pt]
\setistmathTF*001
\xtdistance{15mm}{30mm}
\istroot{0}[initial node]{Child}
  \istb{Good}[above left]{(0,2)}
  \istb{Bad}[above right]
\endist
\istroot{1}{(0-2)<30}{Parent}
  \istb{Forgive}[above left]{(1,1)}
  \istb{Punish}[above right]{(-1,-1)}
\endist
\end{istgame}

\begin{istgame}[font=\normalsize]
\xtdistance{10mm}{20mm}
\istroot{0}{Vote}
  \istb{a}[al]{x}
  \istb{b}[ar]
\endist
\istroot{1}{[yshift=-1.5em]0-2}{Vote}
  \istb{c}[al]{y}
  \istb{d}[ar]{z}
\endist
\end{istgame}

\begin{tikzpicture}
  \node (Child) {Child};
  \node (Good) at (1,1) {Good};
  \node (Bad) at (1,-1) {Bad};
  \node (Parent) at (0,0) {Parent};
  \draw[->] (Child) -- node[below, sloped] {$p$} (Good) node[above, sloped] {\emph{Good}};
  \draw[->] (Child) -- node[below, sloped] {$1-p$} (Bad) node[above, sloped] {\emph{Bad}};
  \draw[->] (Parent) -- node[above, sloped] {$q$} (Forgive) node[below, sloped] {\emph{Forgive}};
  \draw[->] (Parent) -- node[above, sloped] {$1-q$} (Punish) node[below, sloped] {\emph{Punish}};
\end{tikzpicture}

\begin{tikzpicture}
  \node (Vote) at (0,0) {Vote};
  \node (a) at (-1,1) {a};
  \node (b) at (1,1) {b};
  \node (c) at (-1,-1) {c};
  \node (d) at (1,-1) {d};
  \draw[->] (Vote) -- node[above, sloped] {$x$} (a);
  \draw[->] (Vote) -- node[above, sloped] {$y$} (b);
  \draw[->] (Vote) -- node[above, sloped] {$c$} (c);
  \draw[->] (Vote) -- node[above, sloped] {$z$} (d);
\end{tikzpicture}

\% dual sloped action labels (\texttt{\istB})
\begin{istgame}
\setistmathTF*001 \% action labels in italics
\xtShowArrows
\xtdistance{15mm}{30mm}
\istroot{0}[initial node]{Child}
  \istb{Good}[above, sloped]{$p$}[below, sloped]{(0,2)}
  \istb{Bad}[above, sloped]{$1-p$}[below, sloped]
\endist
\istroot{1}{(0-2)<30}{Parent}
  \istb{Forgive}[above, sloped]{$q$}[below, sloped]{(1,1)}
  \istb{Punish}[above, sloped]{$1-q$}[below, sloped]{(-1,-1)}
\endist
\end{istgame}

\% IGT 218.1 (Osborne, 2004b)
\begin{istgame}[font=\normalsize]
\xtdistance{10mm}{20mm}
\istroot{0}{Vote}
  \istb{a}[al]{x}
  \istb{b}[ar]
\endist
\istroot{1}{[yshift=-1.5em]0-2}{Vote}
  \istb{c}[al]{y}
  \istb{d}[ar]{z}
\endist
\end{istgame}
% information set
\begin{istgame}
\xtdistance{10mm}{30mm}
\istroot(0){1}
\quad \istb{L}[al] \quad \istb{R}[ar]
\endist
\xtdistance{7mm}{15mm}
\istroot(1a)(0-1)
\quad \istb{a}[al]{1,0} \quad \istb{b}[ar]{2,3}
\endist
\istroot(1b)(0-2)
\quad \istb{c}[al]{0,1} \quad \istb{d}[ar]{-1,0}
\endist
\xtInfoset(1a)(1b){2}
\end{istgame}

% information set
\begin{istgame}
\xtShowEndPoints[oval node]
\xtdistance{10mm}{30mm}
\istroot(0){1}
\quad \istb{L}[al] \quad \istb{R}[ar]
\endist
\xtdistance{7mm}{15mm}
\istroot(1a)(0-1)
\quad \istb{a}[al]{1,0} \quad \istb{b}[ar]{2,3}
\endist
\istroot(1b)(0-2)
\quad \istb{c}[al]{0,1} \quad \istb{d}[ar]{-1,0}
\endist
\xtInfoset[\text{bend left=30}](1a)(1b){2}
\end{istgame}

% (oval) information set
\begin{istgame}
\xtdistance{15mm}{30mm}
\istroot[-135](0)[\text{initial node}]<0>{1}
\quad \istb{A}[al]{(2,2)} \quad \istb{D}[ar]
\endist
\istroot(1)(0-2)<left>{1}
\quad \istb{L}[al] \quad \istb{R}[ar]
\endist
\xtInfoset(1-1)(1-2){2}
\xtdistance{10mm}{20mm}
\istroot(2)(1-1)
\quad \istb{\ell}[al]{(4,2)} \quad \istb{r}[ar]{(1,1)}
\endist
\istroot(3)(1-2)
\quad \istb{\ell}[al]{(3,2)} \quad \istb{r}[ar]{(0,3)}
\endist
\end{istgame}
16.2 A game tree with a strategic game

\begin{tabular}{|c|c|c|}
\hline
$B$ & $3,1$ & $0,0$ \\
\hline
$S$ & $0,0$ & $1,3$ \\
\hline
\end{tabular}

\begin{istgame}
\setistmathTF
\xtdistance{10mm}{40mm}
\istroot(0)[initial node]{1}
\istb(Book)[al]{2,2}
\istb(Concert)[ar]
\endist
\xtPayoff(0-2){\strategicgame}[below,xshift=-7pt]
\end{istgame}

16.3 Larger game trees with information sets

\begin{istgame}
\xtShowEndPoints
\xtdistance{10mm}{40mm}
\istroot(0)[initial node]{1} \istb \istb \istb \endist
\xtdistance{10mm}{10mm}
\istroot(1)[0-1] \istb \istb \istb \endist
\istroot(2)[0-2] \istb \istb \istb \endist
\xtdistance{10mm}{20mm}
\istroot(3)[0-3] \istb \istb \endist
\xtdistance{10mm}{7mm}
\istroot(a)[1-3]{3} \istb \istb \istb \endist
\xtdistance{10mm}{14mm}
\istroot(b)[2-3] \istb \istb \endist
\istroot(c)[3-1]{2} \istb \istb \endist
\istroot(d)[3-2]{2} \istb \istb \endist
\xtInfosetO[fill=red!20](0)(0)
\xtInfoset(1)(2){2}
\xtCInfosetO[fill=blue!20](a)(a)
\setxtinfosetstyle{blue,thick,dashed}
\xtInfoset(b)(3){3}
\setxtinfosetstyle % restore defaults
\xtInfoset(0)(d)(d)
\end{istgame}
16.4 A continuum of branches
16.5 Tic-tac-toe (sketch)

% tic-tac-toe (sketch)
\begin{istgame}[scale=1.8,font=\tiny]
\istroot(0) \istb \istb \istb \istb \istb \istb \istb[\dots] \istb \istb \istb\istb[9][r] 
\endist 
\foreach \x in {1,...,4}
{\xtActionLabel(0)(0-\x){\x}[l]}
\xtdistance{10mm}{2mm}
\istroot(A)(a1-3) \istb[2][1] \istb \istb \istb \istb \istb \istb\istb[9][r] \endist 
\istroot(B)(a1-8) \istb[2][1] \istb \istb \istb \istb \istb \istb\istb[8][r] \endist 
\istroot(C)(a7-8) \istb[1][1] \istb \istb \istb \istb \istb \istb\istb[8][r] \endist 
\istroot(Bx)(B-7) \istb[2][1] \istb \istb \istb \istb \istb \istb\istb[7][r] \endist 
\istroot(By)(Bx-1) \istb[3][1] \istb \istb \istb \istb\istb[7][r] \endist 
\istroot(Bz)(By-1) \istb[4][1] \istb \istb \istb \istb\istb[7][r] \endist 
\xtPayoff(Bz-4){\vdots} \xtPayoff(Bz-4){\cdots}[right,xshift=10pt] 
\end{istgame}
16.6 Selten’s horse

\begin{istgame}
\xtdistance{6mm}{16mm}
\istroot[45]{0}[initial node]{1}
\istb[D]{r}
\istb<grow=east, level distance=30mm>{C}{a}
\endist
\istroot(1)(0-1)+10mm..20mm+
\istb[L]{al}{3,3,2}
\istb[R]{ar}{0,0,0}
\endist
\istroot[-45](a)(0-2){2}
\istb[d]{r}
\istb<grow=0, level distance=20mm>{c}{a}{1,1,1}[r]
\endist
\xtInfoset(1)(a1){3}
\end{istgame}
\captionof{figure}{IGT 331.2}

Figure 2: IGT 331.2

16.7 Centipede game

\begin{istgame}[scale=1.5]
\setistmathTF\ast001
\setistgrowdirection{south east}
\xtdistance{10mm}{20mm}
\istroot(0)[initial node]{1}
\istb[Take]{r}{(2,0)}[b] \istb{Pass}{a} \endist
\istroot(1)(0-2){2}
\istb[Take]{r}{(1,3)}[b] \istb{Pass}{a} \endist
\istroot(2)(1-2){1}
\istb[Take]{r}{(4,2)}[b] \istb{Pass}[a] \endist
\xtInfoset(2-2){(xshift=5mm)2-2}
\begin{istgame}
\istroot(3){(xshift=5mm)2-2}{2}
\istb[Take]{r}{(97,99)}[b] \istb{Pass}{a} \endist
\istroot(4)(3-2){1}
\istb[Take]{r}{(100,98)}[b] \istb{Pass}{a} \endist
\istroot(5)(4-2){2}
\istb[Take]{r}{(99,101)}[b] \istb{Pass}[a]{(100,100)}[r] \endist
\end{istgame}

\begin{istgame}
\istroot(0)[initial node]{1}
\istb[Take]{r}{(2,0)}[b] \istb{Pass}{a} \endist
\istroot(1)(0-1)+10mm..20mm+
\istb[L]{al}{3,3,2}
\istb[R]{ar}{0,0,0}
\endist
\istroot[-45](a)(0-2){2}
\istb[d]{r}
\istb<grow=0, level distance=20mm>{c}{a}{1,1,1}[r]
\endist
\xtInfoset(1)(a1){3}
\end{istgame}

16.8 Poker game

\begin{lstlisting}[language=TeX]
\% poker: growing south
\begin{isetgame}[scale=1.7]
\setistmathTF*001
\xtShowEndPoints
\xtdistance{15mm}{30mm}
\istroot(0) [chance node]{N}
\istB{Black}[al]{$\frac{1}{2}$}[br]
\istB{Red}[ar]{$\frac{1}{2}$}[bl]
\endist
\xtdistance{15mm}{30mm}
\istroot(1-1)(0-1){1}
\istbA(.5)<grow=-135>{Fold}[al]{1,-1}
\istb{Raise}[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(1){1-1-2}
\istb{Pass}[al]{1,-1}
\istb{Meet}[ar]{2,-2}
\endist
\xtdistance{15mm}{30mm}
\istroot(1-2)(0-2){1}
\istbA(.5)<grow=-135>{Fold}[al]{-1,1}
\istb{Raise}[ar]
\endist
\xtdistance{10mm}{20mm}
\istroot(2){1-2-2}
\istb{Pass}[al]{1,-1}
\istb{Meet}[ar]{-2,2}
\endist
\xtInfoset(1){2}{2}
\end{isetgame}
\end{lstlisting}

N

Black

Red

1

1

1

1

\begin{tikzpicture}
\node (root) at (0,0) {N};
\node (black) at (-1,-2) {1};
\node (red) at (1,-2) {1};
\node (fold) at (-1,0) {Fold};
\node (raise) at (1,0) {Raise};
\node (pass) at (-1,-4) {Pass};
\node (meet) at (1,-4) {Meet};
\node (black_red) at (0,-2) {Black \ Red};
\node (black_1) at (-1,-2) {Black \ 1};
\node (red_1) at (1,-2) {Red \ 1};
\node (fold_1) at (-1,0) {Fold \ 1};
\node (raise_1) at (1,0) {Raise \ 1};
\node (pass_1) at (-1,-4) {Pass \ 1};
\node (meet_1) at (1,-4) {Meet \ 1};
\node (pass_2) at (-1,-6) {Pass \ 2};
\node (meet_2) at (1,-6) {Meet \ 2};
\node (pass_3) at (-1,-8) {Pass \ 3};
\node (meet_3) at (1,-8) {Meet \ 3};
\node (pass_4) at (-1,-10) {Pass \ 4};
\node (meet_4) at (1,-10) {Meet \ 4};
\end{tikzpicture}
16.9 Poker game: growing to the right

\begin{tikzpicture}[scale=1.3]
\setistmathTF 001
\setistgrodirection{0}\% default grow-direction is 'east' from now on
\istdistance{15mm}{30mm}
\istroot{0}[chance node]<left>{N}
  \istB{Black}[bl]{$\frac{1}{2}$}[ar]
  \istB{Red}[al]{$\frac{1}{2}$}[br]
\endist
\istdistance{15mm}{30mm}
\istroot{1-1}(0-1)<left>{1}
  \istb{grow=-45, level distance=10mm}{Fold}[bl]{1,-1}
  \istb{Raise}[al]
\endist
\istdistance{12mm}{24mm}
\istroot{1}(1-1-2)
  \istb{Pass}[bl]{1,-1}
  \istb{Meet}[al]{2,-2}
\endist
\istdistance{15mm}{30mm}
\istroot{1-2}(0-2)<left>{1}
  \istb{grow=-45, level distance=10mm}{Fold}[bl]{-1,1}[xshift=5pt]below
  \istb{Raise}[al]
\endist
\istdistance{12mm}{24mm}
\istroot{2}(1-2-2)
  \istb{Pass}[bl]{1,-1}
  \istb{Meet}[al]{-2,2}
\endist
\xtC Infoset0[fill=blue!20]{1-1-2}{1-2-2}{2}
\end{tikzpicture}
\begin{istgame}[scale=1.3]
\setistmathTF*001
\setistgrowdirection'{0} \% \setistgrowdirection'
\istroot{0}[chance node]<left>{N}
  \istB{Black}[al]{$\frac{1}{2}$}[br]
  \istB{Red}[bl]{$\frac{1}{2}$}[ar]
\endist
\istroot{(1-1)(0-1)}<left>{1}
  \istb{grow=45,level distance=10mm}{Fold}[al]{1,-1}
  \istb{Raise}[bl]
\endist
\istroot{(1)(1-1-2)}
  \istb{Pass}[al]{1,-1}
  \istb{Meet}[bl]{2,-2}
\endist
\istroot{(1-2)(0-2)}<left>{1}
  \istb{grow=45,level distance=10mm}{Fold}[al]{-1,1}
  \istb{Raise}[bl]
\endist
\istroot{(2)(1-2-2)}
  \istb{Pass}[al]{1,-1}
  \istb{Meet}[bl]{-2,2}
\endist
\xtInfosetO[fill=red!20](1-1-2)(1-2-2){2}
\end{istgame}
16.10 Signaling games

% signaling game: IGT 337.1 (Osborne, 2004b)
\begin{istgame}
\setistgrowdirection'{right}
% game start: choice of chance
\xtdistance{20mm}{20mm}
\istroot(0)\{chance node\}<180\{Chance\}
\istB<grow=north>(H)\{1-P\}[r] \istB<grow=south>(L)\{P\}[r] \endist
\istroot(H0)\{0\}<180\{F\}
\istb{(p_1,E)}[a] \endist
\istroot(L0)\{0\}<180\{F\}
\istb{(p_1,E)}[a] \endist
\setistmathTF*001
\cntmdistance{10mm}{20mm}{8mm}
% subtree after H is chosen
\istroot(H)(H0-1)
\istb(Buy)[br] \istb(Refrain)[ar]\{-E,0\} \endist
\istrootcntm(H)(H-1)
\istb{(p_2^-H)}[b] \istbm \endist
\istroot(CH)(H1-1)\{label distance=-4pt\}135\{C\}
\istb(Buy)[br]\{p_1-E-c_H+p_2^-H-c_H, 2H-p_1-p_2^-H\}
\istb(Refrain)[ar]\{p_1-E-c_H, H-p_1\} \endist
% subtree after L is chosen
\istroot(L)(L0-1)
\istb(Buy)[br] \istb(Refrain)[ar]\{-E,0\} \endist
\istrootcntm(L)(L-1)
\istb \istbm \istb{(p_2^-L)}[a] \endist
\istroot(CL)(L1-2)\{label distance=-4pt\}135\{C\}
\istb(Buy)[br]\{p_1-E-c_L+p_2^-L-c_L, 2L-p_1-p_2^-L\}
\istb(Refrain)[ar]\{p_1-E-c_L, L-p_1\} \endist
\xtInfoset(H)(L){C}[left]
\end{istgame}
Version history

- v2.0 (2019/01/27) to be upload to CTAN
  - changed the title of the package to “Draw Game Trees with TikZ”
  - package document done

- v2.0rc (2019/01/27)
  - introduced \setxtinfosetstyle
    * introduced infoset style, a new style for information sets
    * modified all definitions of information sets, accordingly
  - redefined macros related to layer, to easily restore default values
  - modified the cross arrow tip options
  - modified defaults of \setxtarrowtips not to depend on branch styles initially
  - code refinement

- v2.0beta1 (2019/01/26)
  - introduced \xtshowXpoints and \xtshowXcircles (for developer only, not documented)

- v1.0 (2017/09/04)
– introduced \cntmlevdist and \cntmsibdist
– introduced \cntmdistance
– redefined related marcos
– package document done

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